Human Anatomy & Physiology I

General

this course emphasizes the relationship between anatomy and physiology

More conceptual approach, interactions stressed

→ need some of both to truly understand how the body works

Anatomy [Greek: 'to cut up']

the study of parts and their interrelationships

how the body is organized

What are you, What are you made of?

8 or 10 major organ systems
dozens of tissues and organs
a conglomeration of trillions of cells
a collection of carefully arranged atoms and molecules interacting in millions of different ways

provides a standardized language

e.g. "stomach" means different things to different people

Physiology

is the study of biological functions

How does your body work?

all functions of the body involve chemical reactions
cells function by manipulating energy and matter

= metabolism
the whole process is regulated by your "genes"
as long as you give your body adequate food it can run automatically

Models

biology is very complex

How can we organize and study such complex processes?

→ must simplify to understand but

the English satirist, Samuel Butler proclaimed that the human body was merely "a pair of pincers set over a bellows and a stewpan and the whole thing fixed upon stilts"

→ lose something in the translation

Use models to understand complex processes

there are many different kinds of models

some very simple, some extremely elaborate

e.g. a philosopher's model of the human body: "the body is nature's way of learning about itself"

Some Examples of Models in Physiology:

1. Major Organs & Organ Systems

need "organs and organ systems" to coordinate and control all this activity

but these systems can mean different things to different people

thinking of the body in terms of Organ Systems can also be an oversimplification

e.g. immune system, lymphatic system, integumentary system, neuroendocrine system

even within a system there can be variations:

anatomy texts present the anatomy seen in ~70% of individuals

→ the most common versions

eg. some people completely lack certain organs (palmaris longus in forearm, plantaris in leg)

eg. most have 5 lumbar vertebrae but some have 4 or 6

eg. most have one spleen but some have 2

eg. most kidneys are supplied by a single renal artery and drained by one ureter, but some have 2 arteries or ureters

2. Levels of structural organization: [Hierarchy of complexity]

What are you?

matter, energy and their interactions can be applied at many levels in biological systems

→ a collection of carefully arranged atoms and molecules all continuously interacting and reacting with each other

→ a conglomeration of 100 trillion cells, each orchestrating its own sets of activities; metabolism, transport, replication, etc

→ clumps and sheets of specialized cells called tissues designed to perform functions such as storage, movement, impulse conduction, support, etc

→ organs systems composed of dozens of organs interacting with each other to perform vital functions such as digestion, respiration, excretion, reproduction, etc

moving up scale each level is more complex
than one below it
each level includes all those below it
new properties emerge from each level
in terms of energy, each unit is more unstable
than the one below it

atoms—smallest structural units of matter
(protons, neutrons, electrons)
molecules—interaction of atoms to form
compounds
organelles—specialized components of cells
performing specific cellular functions
cells—basic unit of life
tissues—groups of cells carrying out a
specific function
organs—groups of tissues performing given
functions
organ systems—group of interacting
organs
organism—total functioning unit

[population—association of same species living
in same habitat]
[community—populations of several different
species living in same place]
[ecosystem—highest level of biological
organization]
most complex
environment and community and all
interactions]

Learn different things by studying at different

3. Homeostasis

Homeostasis: the ability to maintain a constant
internal environment regardless of fluctuations
in the external environment

→ boundaries are needed

factors of the internal environment that
must be maintained in homeostasis:

→ concentration of nutrient molecules
→ concentrations of O₂ and CO₂
→ concentrations of waste products
→ pH
→ concentrations of water, salts and other electrolytes
→ temperature
→ blood volume and pressure

Requires:

receptor → control center → effectors

receptors can be:
complex sense organs
individual cells
receptor molecules on cells

control center can be:

brain
individual organs
effectors can be:
muscles (smooth, skeletal, cardiac)
glands

homeostasis is maintained mainly by process of
negative feedback

Negative Feedback: when a change in one
direction triggers a response in the opposite
direction

has intrinsic controls and set points

examples

In some instances, positive feedback works to
return body to homeostasis

= a change in one direction stimulates further
change in the same direction (= cascades)

but must have an end point

eg. clotting, immune response, labor,

but uncontrolled Positive Feedback causes
Homeostatic imbalances; disease and even death

4. Categorizing Disorders and Diseases

we learn about “normal” anatomy & physiology in
order to understand disease and how it affects
the body

disease = any change from the general state of good health

Kinds of Diseases

a. injury
b. infectious diseases
c. genetic diseases
d. autoimmune diseases
e. degenerative & age related diseases
f. occupational
g. environmental

eg. infectious diseases

any condition that is the result of an infectious agent:
viruses, prions, bacteria, fungi, helminths, etc

eg. genetic diseases

some diseases are due to genetic mutations

eg. Hemophilia, Sickle Cell Anemia, etc

studies of incidence of diseases among twins, blood
relatives and spouses and among blacks in different
economic strata all suggested that inheritance plays a
key role in the development course and outcome of
certain diseases
poverty, social conditions, economic stress may only be a compounding factor

genetic differences due to race are minimal → 99.9% of the genomes are similar, but...

eg. Native Americans and Hispanics have higher rates of diabetes than blacks

eq. African Americans seem to suffer from: hypertension, heart disease, prostate and breast cancer, asthma, glaucoma, obesity (60% more prevalent) more frequently than caucasians

eq. black women are more likely to suffer from more aggressive forms of breast cancer; are three to four times more likely to develop lupus; and are up to 9 times more likely to develop uterine fibroids than white women

eq. beta blockers help 3/5 whites with hypertension, but only 2/5 blacks

eq. tamoxifin works less well in preventing recurrence of breast cancer in black women than in white women

eq. Nitromed seems promising in treating blacks with heart diseases but has no significant effects for whites

"when it comes to medicine its very foolish to be color blind"

eq. autoimmune diseases

what are normally the body’s defenses become out of control cascades

eq. some forms of diabetes, lupus, some kinds of arthritis

eq. errors in diagnosis

10% of hospital deaths in US are due to misdiagnosis (AAS ~96)
nmost commonly misdiagnosed:

eq. blood clots in lungs → eg misdiagnosed as heart attack

eq. infections and bleeding → diverticulitis → eg misdiagnosed as inoperable tumor

highest rates of diagnosis error were in small community hospitals which also perform the fewest autopsies

Fields of Study in Anatomy & Physiology:

- gross anatomy
- micro anatomy
- developmental physiology
- pathophysiology
- molecular physiology
- surface anatomy
- cytology
- histology
- ultrastructure
- radiology
- etc

The Language of Anatomy

to study the body we need to establish landmarks and common terminology

Anatomical Position

anatomical position serves as a reference point in locating various parts of the body.

any reference to right or left is referring to the subject

1. Directional Terms

dorsal/ventral (anterior/posterior)
toward the back vs toward the front of the body

superior/inferior (cephalad/caudal)
toward the head vs toward the feet

proximal/distal
pertaining to the limbs: toward the point of attachment vs away from the point of attachment

medial/lateral
pertaining to the trunk: toward the midline of the body vs away from the midline of the body

2. Body surface landmarks
A. General Body Regions:
   a. axial region:
      - head
      - neck (cervical)
      - trunk
      - thorax
      - abdomen
   b. appendicular region
      - upper limbs
      - lower limbs

B. Surface Landmarks:
   look up the definitions of each of these terms in your text:
   - head, neck, thorax, abdomen, pelvis, perineum, nasal, orbital, oral, buccal, occipital, cervical, acromial, axillary, thoracic, umbilical, vertebral, lumbar, sacral, gluteal, brachial, antebrachial, pelvic, digital, abdominal, pubic, inguinal, perineal, femoral, patellar, popliteal, crural, pedal, calcaneal

3. Body Planes & Sections
   - sagittal (including mid-sagittal)
     divides the body or an organ into right and left portions
   - frontal (coronal)
     divides the body or an organ into front and back portions
   - transverse (cross)

4. Body Cavities
   viscera (~body organs) are contained within distinct cavities within the body
   - dorsal: cranial, spinal
   - ventral: thoracic, pleural, pericardial, abdominopelvic, abdominal, pelvic
   - minor cavities: oral cavity, nasal cavity

5. Subdivisions of abdominopelvic cavity:
   the abdominopelvic cavity contains most of our internal organs and is therefore conveniently subdivided into smaller areas:
   - quadrates – divides it into 4 parts
   - 9 regions – divides it into 9 parts

6. Surface examinations:
   a. palpation – feeling with firm pressure
      For: all bones – good landmarks
      many muscles
      some veins and arteries
      nerves
      lymph nodes
      glands
      some internal organs, eg liver
   b. percussion - tapping sharply
      For: fluid concentrations
      organ densities
   c. auscultation - sounds that various organs make
      For: breathing
      heartbeat
      digestive sounds
   d. reflexes - condition of nervous system
      uses tendon tapping

7. Imaging
   a. Microscopy: an examination of small structures only visible using a microscope
      microscopes were invented in the 1600’s and opened up a whole new world of biological discovery.
   i. Light Microscopy
      uses a beam of light to magnify objects up to 2000x’s
      requires elaborate steps to prepare and stain the slides
      relatively low resolution at higher magnifications
   ii. Transmission Electron Microscopy
      also requires sectioning and elaborate preparations
      can achieve much higher magnifications and much better resolution
   iii. Scanning Electron Microscopy
      provides 3-D images of whole, unsectioned materials with striking clarity

   b. Medical Imaging
      i. X-Rays
      used in medicine since their discovery in 1895.
the absorption of x-rays depends on the density of the material as they pass through the body to a piece of film beneath. The denser the organ, the lighter the image since less radiation reaches the film especially good for bones not as good for soft tissues.

**ii. Computed (Axial) Tomography (CT or CAT Scans)**

Highly detailed x-ray images are taken around the entire circumference of the body and combined together producing an excellent section images of soft tissue. Generally a good diagnostic tool, can be used quickly for trauma and to assess internal injury not as useful for nervous tissue and joint images.

**iii. Angiography (=“vessel imaging”)**

Produces images of blood vessels also image forms slowly so can’t record rapid changes in activity.

**v. Sonography (Ultrasound Imaging)**

Body is probed with pulses of high frequency sound waves that ‘echo’ off of internal tissues. A computer is used to construct an image much less expensive than other imaging techniques safer and less damaging to tissues used especially for fetal imaging, gall bladder problems not useful for lungs or structures inclosed by bone.

**vi. Magnetic Resonance Imaging (MRI)**

Discriminates between tissues by their water content using magnetic fields up to 60,000 times stronger than earth’s magnetic field the hydrogen atoms in water react to the magnetic field and a pulse of radio waves to radio waves that can be recorded. Does not use radiation to produce an image produces high contrast images of soft tissue much better than x-rays not useful for trauma patients or patients using traction or life support equipment also more sensitive to patient movements.

**vi. Functional MRI (fMRI)**

A modification of the above technique that measures blood oxygen revealing the amount of oxygenated blood flowing to specific areas of the body much more accurate in measuring localized brain activity than PET scans.
What Is Life?

Biology is the study of life
but, what exactly is life?

how are living things different from nonliving things
   eg. a human from a rock
   eg. a a human from a robot
   eg. a living human from a corpse

also, how are all living organisms similar
   → what do we have in common with
      eg. a bacterium
      eg. a fish
      eg. a frog
      eg. an armadillo

So one of the most basic questions is:
   What is Life?

   a highly organized interaction of matter and energy

   can’t define in one sentence

   must consider several properties of life or life functions:

   each property taken individually is NOT unique to living things

   many nonliving things do one or more of them
      eg. viruses don’t quite fit

Properties of Life

1. maintaining boundaries
   internal versus external environment

2. movement

3. responsiveness
   functions are regulated within and between cells

4. assimilation & digestion

5. metabolism
   anabolism & catabolism

6. excretion

7. reproduction
   survival of genetic information

8. growth

Survival needs:

1. nutrients
   solids, liquids, gasses

2. gaseous oxygen, O₂
   (is actually a nutrient)
   needed for energy reactions in cells

3. water
   solvent
   reactant

4. temperature range near 37° [~0° - 100°]
   need liquid water
   proteins (enzymes) sensitive to temp

5. atmospheric pressure near 760mm Hg
   gas exchange
   air pressure at sea level: about 14 lbs per square inch; winds produce lots of force
   pressure is equivalent to weight of air: a room 12x15x9 ft holds about 170 lbs of air

6. gravity
   space science – gravity is essential for normal bone and muscle maintenance and cardiovascular fitness