Science of Fitness Manual

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The following manual is designed to be a brief review, in preparation for the Science of Fitness event. The Science Olympiad organization was not involved, in any way, with the making of this manual. Participants are encouraged to, not rely solely on this manual, but consider textbooks, articles, etc, for detailed information.

Topic #1 - Nutrition

Daily requirements:

Based on an individual's activity, age, weight, gender, etc. Standard = 2000 calories per day.
To gain weight - take more calories than standard, and to loose weight, reduce caloric intake and increase exercise.

Carbohydrates:

Provide immediate energy and are the primary constituents of a 2000 calorie diet.
50%-60% of 2000 calorie diet or 125g for every 1000 calories. Get Carbohydrates from fruits, vegetables, bread, whole grain but stay away from refined sugars.

Proteins:

Needed for growth, developments, sometimes for energy as well. Requirements is greater in young children than adults. Primary sources are meats.
average = 56 grams per day for men and 44 grams per day for women. Roughly 10% of 2000 calorie diet.

Fats:

Stored sources of energy and the main sources as well. Fats are synthesized by liver and provide Essential fatty acids. These include linelonic acids, linoleic acids. Vegetable oils, and Marine fish are major sources of essential fatty acids.
Essential Fatty Acids = 6-10% of 2000 calorie diet.
Total Fat = 30% of 2000 calorie diet.
Saturated Fat = 10% of 2000 calorie diet.

Cholesterol:

Cholesterol is required by body but sparingly. For example hormonal development, Cell membranes, Vitamin D need cholesterol. Recommended limit is no more than 300 mg per day. Cholesterol is further defined into two types:
High Density Cholesterol (HDL) - can be excreted by liver
Low Density Cholesterol (LDL) -not so good. Can't be excreted by liver and clogs arteries.

Stay away from Transfatty acids found in butter substitutes, processed foods and fatty meats.

Fiber:

Needed to - prevent constipation, reduce blood glucose, reduce chances of cancer in large intestine. Fruits and Vegetables are great sources. Cellulox, hemicellulose, pectin, gums are some important fibers.
Recommended is 30g/per day or 11.5 g per 1000 calories.

Minerals, Vitamins and Trace elements. - Needed for a variety of functions:

Substance	Use	Sources
Minerals:		
Calcium & phosphorous	Teeth, clotting of blood, bones	Milk, dairy products, leafy vegetables
Sodium and potassium	Proper water balance, functioning of heart	Salt, potassium found in bananas
Chlorine	for stomach and gastric juice	Salt and Vegetables
Trace elements:		
Iron	Hemoglobin, respiratory enzymes	Nuts, liver, beef, spinach
Iodine	thyroid gland	seafood
Fluorine	proper tooth formation	added to water now days
Zinc	for metabolic enzymes	seafood, eggs
Chromium	for metabolism of glucose	meat, cheese
Manganese	bone structure	whole grains, fruits
Vitamins:		
A	growth of body, vision in dim light, eyes, reduces susceptibility to cold	carrots, spinach, lettuce, butter and eggs, liver
B1	Nerve function	whole grains, fresh green vegetables
B2	oxidation and energy release, prevents weakness, lack would cause sores	milk, yeast and green vegetables
Niacin	for cell respiration and skin's nervous system	Liver, yeast, peanut butter
B12	for red blood cell, prevents anemia	liver, meats, milk
Folic acid	prevents anemica, heart disease, cancer, reduces homocystine in blood which can cause heart attacks and stroke	leafy vegetabls, fruits, and dreid beans
B6	also for cell respiration	
C	helps form connective tissue, keeps capillaries in good condition	citrus fruits ex- lemon, oranges
D	for proper bone formation ann teeth as well	formed in body upon contact with sunshine
E	for muscles	whole grains
K	clotting of blood	liver, leafy vegetables
Substances and signs of deficiency:		
Substance	*Signs*	
Chromium	glucose intolerance	
Copper	Anemia, osteoperosis, diarrhea	
Iodine	hypothryroidism, goiter	
Iron	anemia	
Manganese	dermatitis	
Selenium	Muscle weakness	
Zinc	growth retardation, skin lesions, diarrhea, mental status change	
Vitamin K(phylloquinone)	easy bruising/bleeding	
Vitamin A(retinol)	night blindness	

Substance	*Signs*	
Vitamin D(ergocalciferol)	rickets, osteoperosis, bone pain, w eak muscles	
Vitamin E(alpha tocopherol)	abnormal cloting, hemolysis	
Vitamin B1(thiamine)	beriberi, cardiac failure, fatigue	
Vitamin B2(riboflavin)	sore tongue and mouth, eye irritation	
Vitamin B3(niacin)	sore mouth and tongue, Pellegra	
Vitamin B6(pyridoxine)	Convulsions	
Vitamin B7(biotin)	Seizures,	
Vitamin B9(folic acid)	Anemia, diarrhea	
Vitamin B12(cobalamin)	Diarrhea, mental status change,	
Vitamin C (ascorbic acid)	Scurvy, acid and bleeding, w eakness, depression	

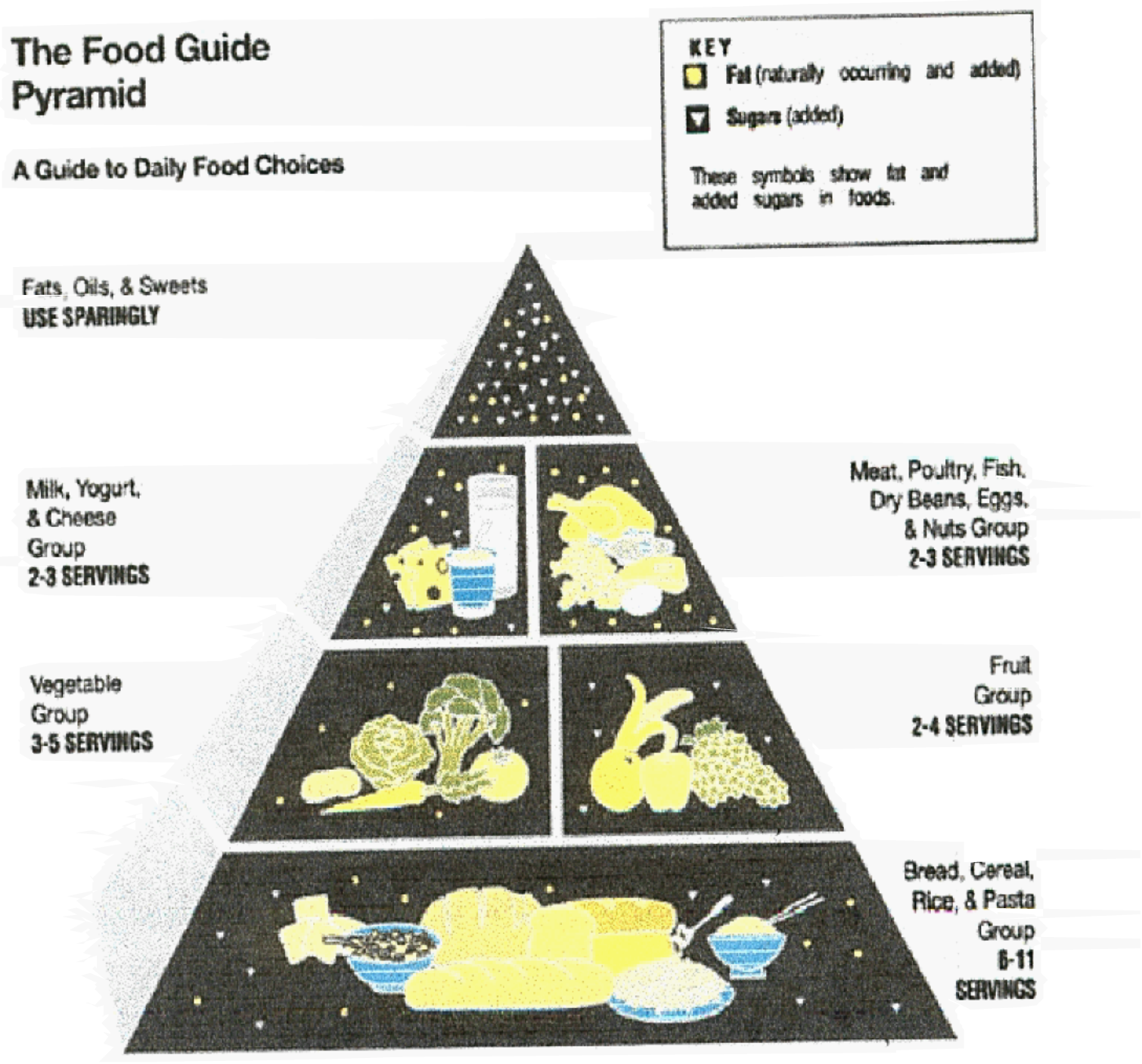
Dietary Standards and Food labels:

Based on % daily values and daily requirements mentioned above.
Based on 2000 calorie diet.

Servings indicated on labels are based on how much of that food is eaten normally. A food item could use cup as a serving unit, while others may use tablespoon, teaspoon, piece, fraction, etc.
Reference Values: Government has set “reference amounts” for all type of foods. These reference values define serving sizes for different categories of foods. For example, Bread has a reference of 50g, so one serving is equal to 50g.
If foods come in discrete units such as cookies, the serving size is the whole number of units that most closely approximate the reference amount. Cookies have a reference amount of 30g. Thus if a package has cookies weighing 6g each, it would take 5 to make one serving.

Additional rules:
If a food weighs more than 50% but less than 200% of a reference amount, it is equal to one serving.

Food Pyramid:
Categorizes foods and dictates consumption.



Daily recommended servings:
Fats and Oils should be used sparingly.
Milk, Cheese, Yogurt - 2-3 servings
Meats, Poultry, Fish, Nuts, eggs - 2-3 servings.
Vegetables - 3-5 servings
Fruits -2-4 servings
Bread, Cereal, Rice, grain - 6-11 servings

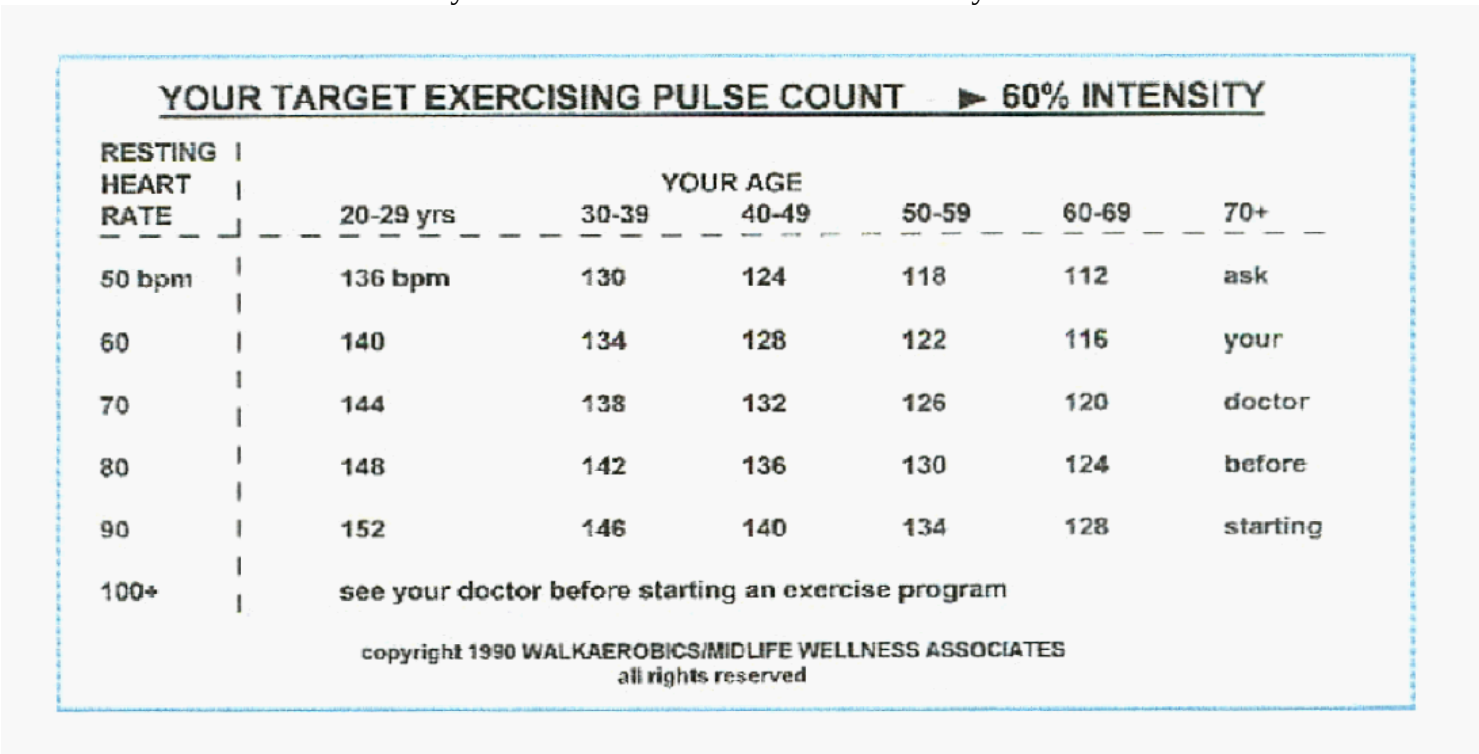
Generally it is recommended that the smallest amount of servings in each category be consumed.

Fats in Pyramid.:
Saturated Fat: meat, dairy products, coconuts
Monosaturated - olive, peanut and canola oil.
Polysaturated - sunflower, corn, soybean, some fish.

FITT principle of exercise:
Describes exercise in terms of frequency, intensity, time, type.

Frequency: Cardiovascular exercise - 3-6 times a week.
Walk aerobics - 2 times a week.
Rest one day for every 3-4 days of exercise.

Intensity:
How intense an exercise should be, is described in terms of what heart beat you want to achieve. Recommended is 60%. See chart below to find what your heart beat should be at 60% intensity.



YOUR TARGET EXERCISING PULSE COUNT ► 60% INTENSITY

RESTING HEART RATE	YOUR AGE 20-29 yrs	30-39	40-49	50-59	60-69	70+
50 bpm	136 bpm	130	124	118	112	ask
60	140	134	128	122	116	your
70	144	138	132	126	120	doctor
80	148	142	136	130	124	before
90	152	146	140	134	128	starting
100+	see your doctor before starting an exercise program					

Max heart rate=maximum intensity - at this rate only 9 seconds of energy available from glycogen. Don't exercise at this intensity.

Sports Heart rate = 80% intensity - exists for short periods of time.

Optimal heart rate = 60% intensity is the best rate especially for burning fat.

Time:
12-60 minutes. The less fit a person, the shorter the duration. Increase time as you get healthier and leaner.

Type:
Brisk Walking
Treadmill
Walk aerobics
Stationary Bikes
Stair climbing
Jogging
Low impact aerobics

The key idea is to use these principles and gradually, train or condition your heart to an optimal 60% heart rate. So increase intensity time, frequency, as you get healthier and when there is an increase in normal heart rate.

Nutrition and Athletes:
Diet with high amount of complex carbohydrates and proteins is best. Carbohydrates and some fats should be the key sources of energy.

Carbohydrates:
55 - 65% of calories should be carbohydrates.
Starches found in breads, cereal, pasta, corn, potatoes, peas and fruits are best.
For short bursts of energy and high intensity sports - carbohydrates should be 100% of diet.
For longer duration, Carbohydrates provide initial energy and then fats become sources of energy.

Carbohydrate loading:
Endurance athletes and those involved in competition for more than 90 minutes should:
1. Take normal carbohydrate diet.
2. In final 3 days, push carbohydrate intake to 65% of total caloric intake. This will increase glycogen storage, which is an important complex carbohydrate.
Fats: Provide stored energy, consumption can be close to carbohydrates. Keep it 30% of diet.

Calculations and concepts:

Calculating Calories per gram:
1 gram carbohydrates = 4 calories
1 gram protein = 4 calories
1 gram fat = 9 calories

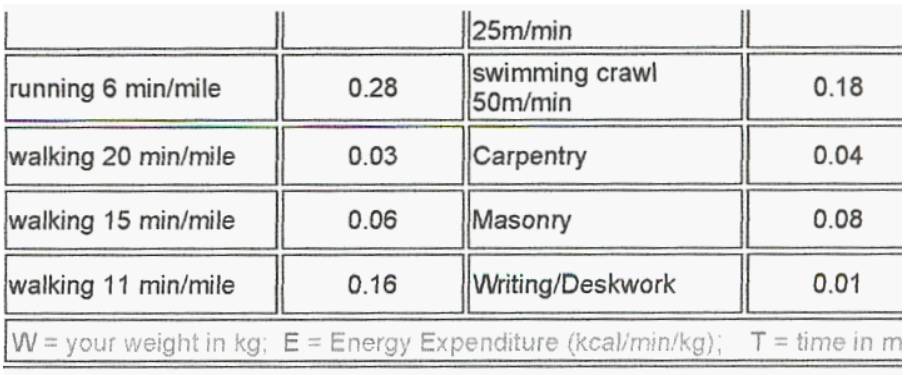
1 gram alcohol = 7 calories

Total caloric requirement = BMR + PA + SDA or 1.1 X (BMR+PA)

BMR = Basal metabolic rate = number of calories needed at rest for normal body function. 60-70% of daily diet.
BMR is calculated with the Harris Benedict equation.
BMR for men = 66 + (13.7 X weight(kg)) + (5 X height(cm)) - (6.8 X age)
BMR for women = 665 + (9.6 X weight(kg)) = (1.8 X height(cm)) - (4.7 X age)

SDA = specific dynamic action - energy required to digest, absorb, transport and metabolize food.
10% of daily diet.

PA= Physical activity (see sample chart below)



		25m/min	
running 6 min/mile	0.28	swimming crawl 50m/min	0.18
walking 20 min/mile	0.03	Carpentry	0.04
walking 15 min/mile	0.06	Masonry	0.08
walking 11 min/mile	0.16	Writing/Deskwork	0.01
W = your weight in kg; E = Energy Expenditure (kcal/min/kg); T = time in m			

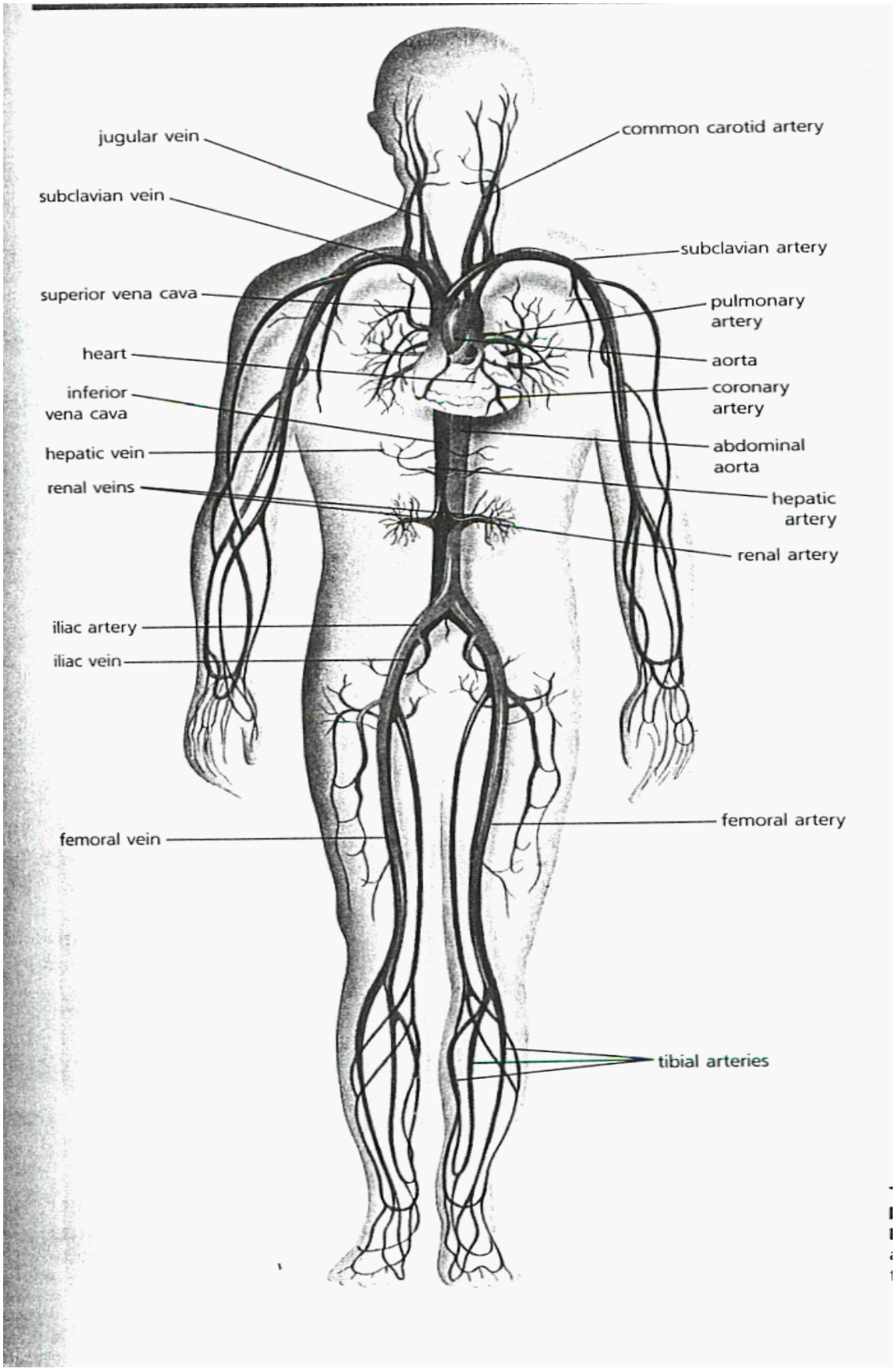
Daily caloric intakes for macronutrients:

Daily Carbohydrate or Fat requirement:
1. Get daily total caloric requirement
2. Multiply by the % of diet that should be fat, carb.
3. If needed, convert it to grams using the conversion factors of calories and grams.

Daily Protein requirement:
Multiply weight by daily protein requirement in grams.

Whew! That's the end of Part 1.

Topic #2 -Heart and circulatory system


jugular vein
common carotid artery
subclavian vein
subclavian artery
superior vena cava
pulmonary artery
heart
aorta
inferior vena cava
coronary artery
abdominal aorta
hepatic vein
hepatic artery
renal veins
renal artery
iliac artery
iliac vein
femoral artery
femoral vein
tibial arteries

Circulatory system components:

Arteries: elastic since it contains elastin and muscle cells. Carry fresh blood away from heart and to rest of body. Major ones include the aorta, pulmonary arteries(only ones to carry deoxygenated blood).

Veins: Carry deoxygenated blood to heart. Veins have low pressure, low resistance, higher cross sectional area, and less elastin and muscle. Valves in veins prevent backflow of blood.

Arterioles: Smaller arteries, less pressure in these.

Capillaries: Connect arteries an veins and allow exchange of oxygen, nutrients, etc. Made of smooth muscle cells.

Heart - Made of four chambers - Left Atria, Right Atria, Left Ventricle and Right Ventricle.

<<<<<Right Left>>>>

Blood Circulation:
Blood enters the right atrium from the Superior (upper) and inferior(lower) vena cava. The blood is pumped into the Right ventricle from where it goes to the pulmonary artery. These arteries carry the deoxygenated blood to the lungs where oxygen is assimilated in the blood. The blood returns to the Left Atrium from the pulmonary veins coming from both lungs. It is then pumped into the left ventricle and into the aorta which sends it to the rest of the body.

Systole = contraction of heart, as it pumps blood into aorta.
Diastole = relaxation of heart as it fills up.

Coronary circulation:
Since heart itself is made of muscles, it also needs blood. The right and left coronary arteries distribute this blood to the heart. Normally about 5% of blood pumped in a minute, goes to the heart. A chemical named adenosin is thought to be influential in increasing supply of oxygen to heart.

Cerebral circulation:
The carotid arteries supply brain with oxygen. A 5-10 second delay can cause unconsciousness.

Cardiovascular stress:
Shock = inadequate delivery of oxygen and nutrient to a critical organ.
Symptoms = agitation, restlessness, lethargy, confusion.
Physical signs = some decrease in CO_2 output and increase in heart rate.

Hypertension = high blood pressure.

Blood pressure:
Systolic = pressure on artery when heart contracts
Diastolic = pressure exerted on arteries when heart relaxes.
Mean arterial pressure = average

Heart rate = the number of times a heart contracts in one minute.
heart rate to breathing ratio = 1:4

Pulse = measure of heart rate
Measuring sites>

Temple = temporal artery
Neck = carotid artery
Underarm = axilary artery
Elbow = bracheal artery
Wrist = radial artery
Groin = phemoral artery
Knee = popleteal artery
Ankle = tibeal artery
Foot = dorsalis pedes artery

Atherosclerosis = blockage in artery hinders blood flow or slows it down.

Topic #3 - Respiratory Physiology

Air enters the body through the nose. Dust particles, bacteria, etc are filtered by hair lining in the nose. Alternatively air can also enter through the mouth. The air then passes into trachea, which divides into 2 bronchi tubes. These tubes go to the lungs where they divide into bronchial tubes that spread out throughout lungs. It then goes into alveoli, where gas exchange occurs. Alveoli are like air sacs with capillaries all around them.

Breathing works using the diaphragm. This muscle, located below the ribs, causes the ribs to move in and out, which allows lung to expand or contract, by filling up with air, or pushing air out.

Inspiration = breathing in air.
Expiration = breathing out air.

Breathing factors:
Lung Muscles - affect the elasticity of lungs and thus intake of gas.
Airway resistance = 80-90% of total resistance = alveolar pressure/rate of gas flow in or out of lungs

Alveolar pressure(Pa) = Pressure difference between alveoli and atmosphere. Higher the pressure, higher the gas flow.

Lung volumes and capacities:
Tidal volumes = volume of gas inspired or expired with each normal breath.
Inspiratory reserve volume = additional gas that can be inspired above the tidal volume, about 3.0 liters average. This is used during exercise.
Expiratory reserve volume = additional gas that can be expired above tidal volume. average = 1.3 liters.
Residual volume = Gas that always remains in lungs after maximum expiration, to prevent lung collapse. average = 1.2 liters.

Capacities:
total lung capacity = the volume of gas after a maximal inspiration.
vital capacity = max volume of gas that can be expired after a maximal inspiration.
inspiratory capacity = max volume of gas that can be inspired after a normal expiration = tidal + Inspiratory reserve volume.

Ventilation:
atmospheric pressure = sea level 760 torr or mmhg.
partial pressure(PP) = the individual pressures of different gases in a mixture of gases, inspired or expired during breathing.
PP of nitrogen = 600 torr
PP of oxygen =160 torr

Minute ventilation = volume of air inspired or expired per minute.

Gas transport:
Gas transport involves the dissolving of gases in blood.
Solubility = partial pressure X solubility coefficient.
Following are solubility coefficients that can vary with temperature:

	Oxygen	Nitrogen	Carbon Dioxide	Carbon Monoxide
0 degree Celsius	0.049	0.024	1.71	0.035
20 degree Celsius	0.032	0.016	0.90	0.023
37 degree Celsius	0.024	0.012	0.58	0.019

Oxygen is carried in Hemoglobin. Oxygen mixes with iron in hemoglobin to form oxyhemoglobin.

CO(carbon monoxide) - decreases O2 content by taking its place in blood. It can take up to 12 hrs for CO to dissociate from hemoglobin.

Respiratory system and stress:
Breathing increases during exercise.
Gas exchange increases in exercise, red blood cell uptake increases to meet greater oxygen consumption and more CO2 is also produced. Minute ventilation increases during exercise.

Topic #4 - Cardiovascular and Respiratory diseases

Cardiovascular:
CVD - cardiovascular disease
5 risk factors - smoking, fat level, blood pressure, Physical inactivity and obesity.

Ischaemia - lack of oxygen due to poor blood supply

Symptoms -chest pain or tightness, poor heart muscle function.

Coronary heart disease (CHD) - Blockage in coronary arteries can cause damage to heart. Leads to heart attack, chest pain. Damage to heart can cause Dysrhythmics = abnormal heart rhythms. Smoking is biggest cause.

Sudden Cardiac death = major blockage can stop heart function.

Stroke or Cerebrovascular accident = damage to brain due to lack of blood and oxygen, blockage can cause and smoking is another factor.

Atherosclerosis (PVD) - Blockage between or within blood vessels prevents proper blood circulation. This can cause pain and even death, or lack of function in the part of body where it occurs. Smoking is bi factor as are fats. This disease also weakens the aorta.

Respiratory:
COPD -chronic obstructive pulmonary disease.
Prevents airflow mostly due o smoking which can have a bad affect on cilia and lungs. It results in secretion of mucus(chronic cough), breathing difficulty, reduction in lung volume and capacity, and ultimately, the loss of lung function.

Lung cancer - cancer tissue in lungs. Biggest factor is smoking. Pollution, radiation, asbestos can also cause this. Symptoms include - cough, bloody sputum, shortness of breath, chest pain, loss of appetite, weight loss.

Emphysema - Damage to the alveoli, causes loss of elasticity and reduces the ability of alveoli to expand completely and collect air. Symptoms include - chronic cough, bluish skin color, shortness of breath quickly or with mild exertion.

Topic #5 - Smoking, second hand smoking, nicotine, carbon monoxide -

The effects of smoking cannot be exaggerated. Most of the disease listed above, are partly due to smoking.
To put it briefly, smoking damages your heart, lungs causes birth defects, cancers. Through smoking nicotine, tar, metals, butane, enter your body to cause further damage.
Technically speaking, smoking will increase heart rate, while reducing oxygen carrying capability of blood, since the Carbon Monoxide will replace oxygen. Smoking will increase LDL while decreasing LDL, this increasing cholesterol deposit and arterial blockage. Smoking which causes blood to clot will result in further blockages. Smoking can cause cancer in lungs, bladder, kidney, pancreas, larynx, mouth, to name a few.

Nicotine - increases heart rate.
increases blood pressure
makes arteries constrict in arms legs.

Tobacco - harms the cilia in lungs

Tar - builds up at branching point in bronchi, bronchial tubes, etc.

Second hand smoking:

Just as bad as active smoking, and possible worse.
leads to heart disease, lung cancer, respiratory disease, nasal sinus cancer, cervical cancer, stroke, breast cancer.

Carbon Monoxide - colorless, odorless but toxic gas.
Sources - fuel fired furnaces, fireplaces, gas stoves, charcoal grills, yard equipment, automobiles.
Inhibits blood's ability to carry oxygen by combining with hemoglobin to form carboxyhemoglobin.
Symptoms of CO intake can range from headache to death.

Topic #6 - Relevant formulas

- Cardiac output - amount of blood pumped per minute

Cardiac output = heart rate * stroke volume

- Stroke volume = amount of blood pumped in one heart beat

Stroke Volume = End diastolic volume - end systolic volume

- End diastolic volume = amount of blood in heart at the end of diastole

End systolic volume = Blood left in heart after systole.

- BMI (body mass index) = weight in Kg / height in meters (squared).

- Partial pressure of gases = total pressure X fractional concentration.

Fractional concentrations:
Oxygen = 0.21
Nitrogen = 0.77
Carbon Dioxide = 0.3

- Pulse pressure = systolic pressure - diastolic pressure

- Mean arterial pressure = diastolic pressure + ((1/3) X Pulse pressure)

- Ideal body weight:

women - for 5 feet of height = 100 pounds, add 5 pounds for each additional inch.
men - for 5 feet of height = 106 pounds, add 6 pounds for each additional inch.

Etcetera

Epidemiology - study of diseases in a large population.
Prevalence - a proportion designating the portion of a total population that may have a certain disease = total number of diseased / total population.

Incidence = number of new cases that develop in a population over a specified period of time.

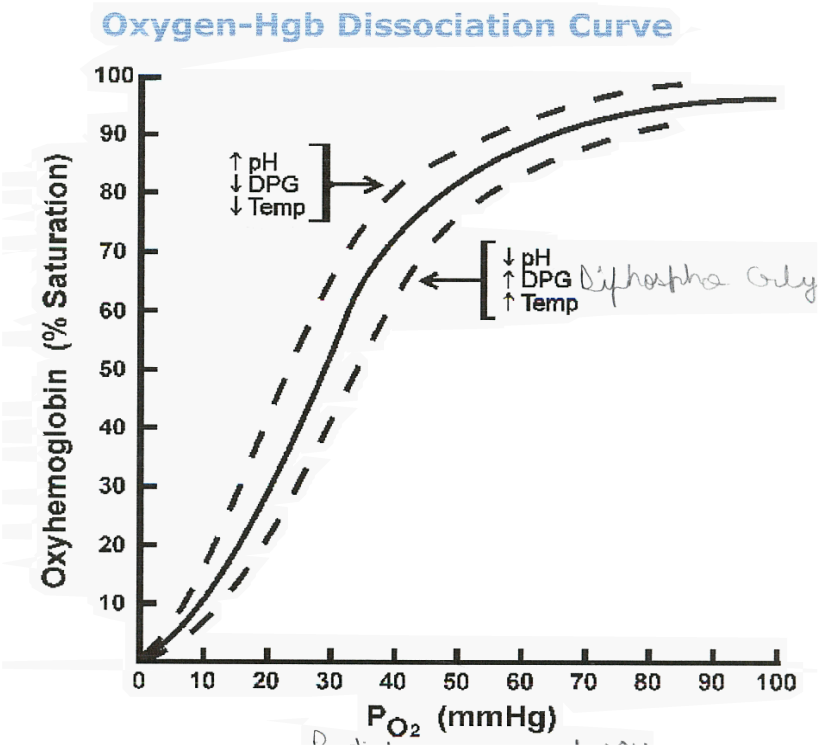
Morbicity rate = total number of people who caught disease but didn't die.
Mortality - same as above but died.

Odd Ratios:
1. Odd ratio = AD/CB
2. Relative risk = A(A+B) / C+(C+D)

The above formulas are based on the following designations:

	Developed disease	Didn't develop disease
Exposed to disease	A	B
Not exposed to disease	C	D

Oxygen dissociation curve:
The oxygen dissociation curve, illustrates oxygen affinity to hemoglobin, in lungs and tissues. The middle black line illustrates normal or theoretical oxygen affinity to hemoglobin. The left-most dotted line, illustrates affinity in lungs, and the right-most shows affinity in tissues. Following is how it all works:



- Affinity increases when ph increases, DPG decreases, and temperature decreases. Affinity decreases or hemoglobin releases more oxygen, when ph decreases, DPG increases and temperature increases.
- The system works quite impressively. In lungs, a greater affinity is desirable, so DPG level is low, ph is high and temperature is down, because there is less activity. However when the hemoglobin goes to tissues, there is a decrease in ph since the tissues are producing acids, from cell respiration, muscle movement, etc. At same time more DPG is released, and high amounts of activity increase temperature, thereby decreasing affinity and increasing release of oxygen.

Thus on the graph, the curve shifts to left, when blood goes to lungs, and shifts right when blood goes to the tissues.

Notice also that, the difference between oxygen saturation in lungs and the saturation in tissues, remains same when partial pressure is within the range of 60-100.