LICENCIATURA EN FISICA MEDICA

BIOFISICA

CAPITULO 1

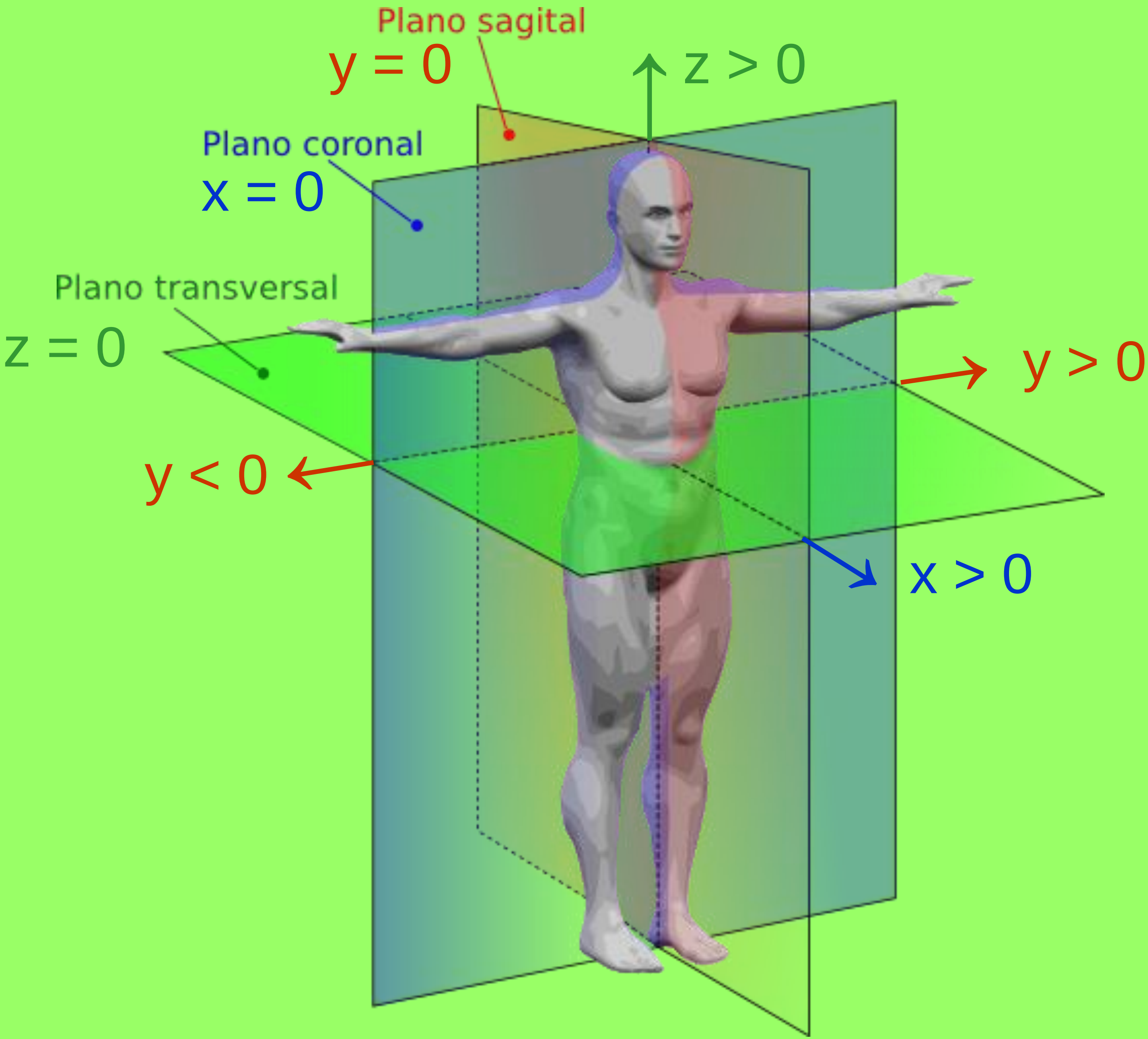
Terminología Anatómica, Cuerpo Humano Estandard, y Escalas.

BIOFISICA

CAPITULO 1

Terminología Anatómica

DIRECCIONES, ORIENTACIONES Y PLANOS ANATOMICOS I



DIRECCIONES, ORIENTACIONES Y PLANOS ANATOMICOS II

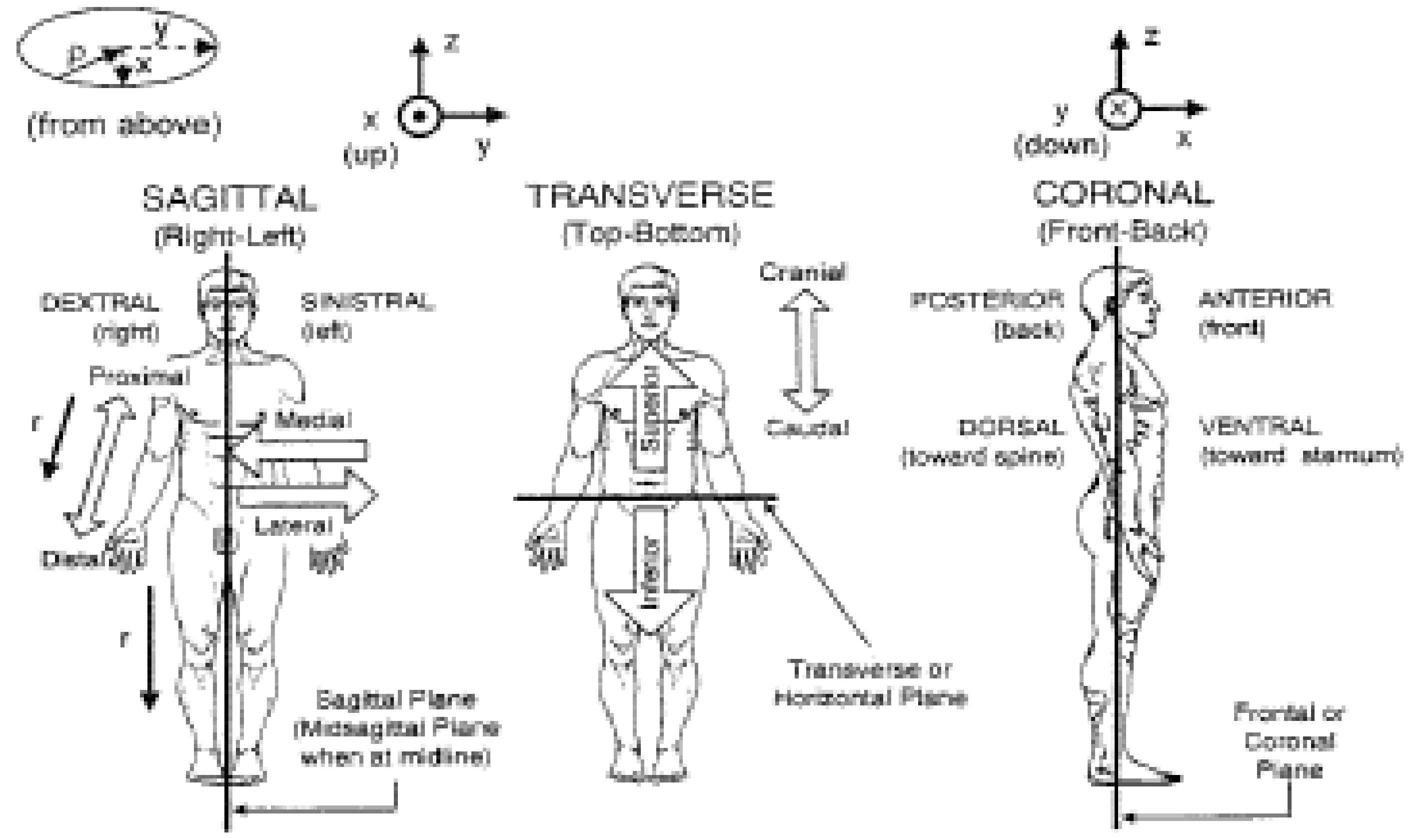


Fig. 1.1. Directions, orientations, and planes used to describe the body in anatomy, along with common coordinate systems described in the text. We will assume both terms in the following pairs mean the same: superior/cranial, inferior/caudal, anterior/ventral, and posterior/dorsal, even though there may be fine distinctions in what they mean, as is depicted here. (From [43], with additions. Used with permission)

Table 1.1. Anatomical terms in anterior regions

anatomical term	common term
abdominal	abdomen
antebrachial	forearm
axilliary	armpit
brachial	upper arm
buccal	cheek
carpal	wrist
cephalic	head
cervical	neck
coxal	hip
crural	front of leg
digital	finger or toe
frontal	forehead
iguinal	groin
lingual	tongue
mammary	breast
mental	chin
nasal	nose
oral	mouth
palmar	palm
pedal	foot
sternal	breastbone
tarsal	ankle
thoracic	chest
umbilical	navel

TERMINOS ANATOMICOS DE LA REGION ANTERIOR

TERMINOS ANATOMICOS DE LA REGION POSTERIOR

Table 1.2. Anatomical terms in posterior regions

anatomical term	common term
acromial	top of shoulder
femoral	thigh
gluteal	buttock
occipital	back of head
plantar	sole of foot
popliteal	back of knee
sacral	between hips
sural	back of leg
vertebral	spinal column

BIOFISICA

CAPITULO 1

Movimientos en el Cuerpo Humano

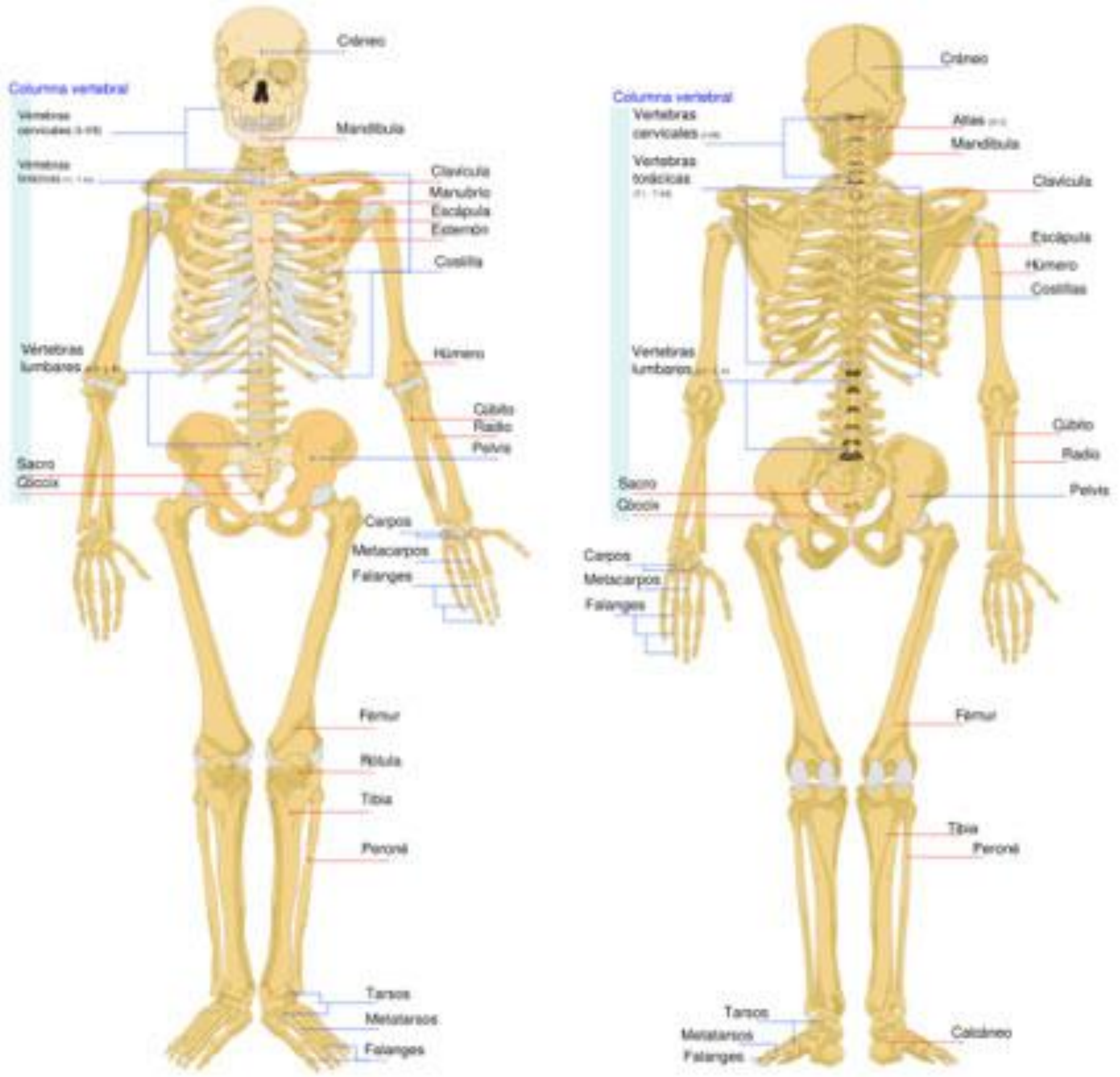
Huesos

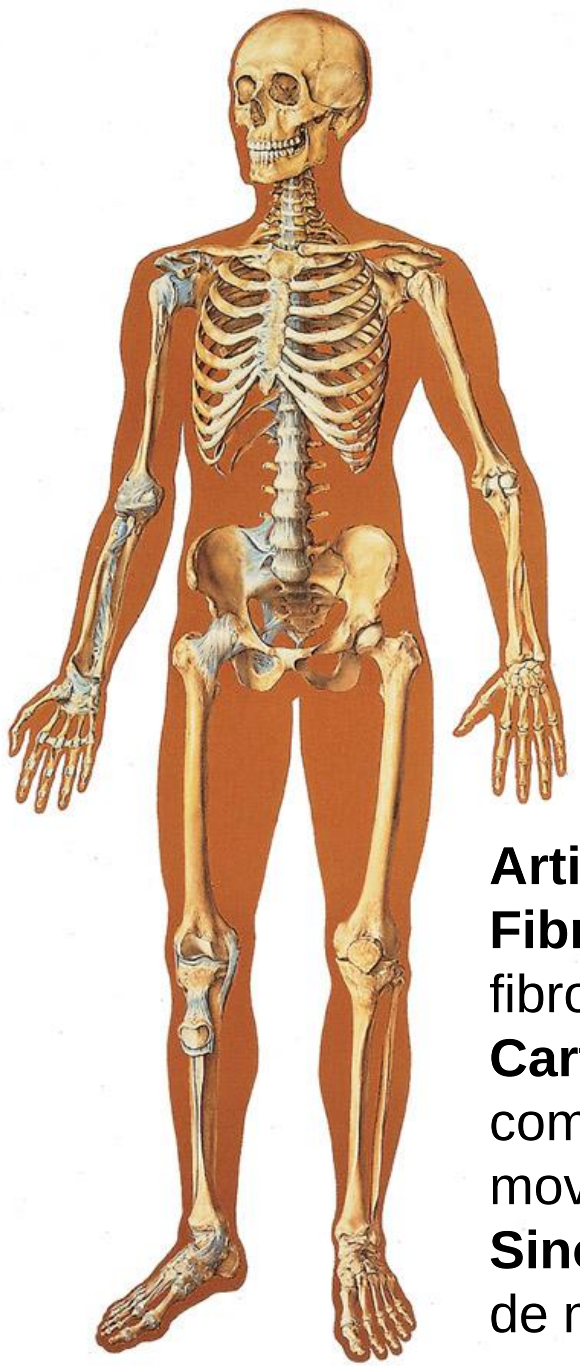
Ligamentos

Músculos

Tendones

SISTEMA ESQUELETAL HUMANO

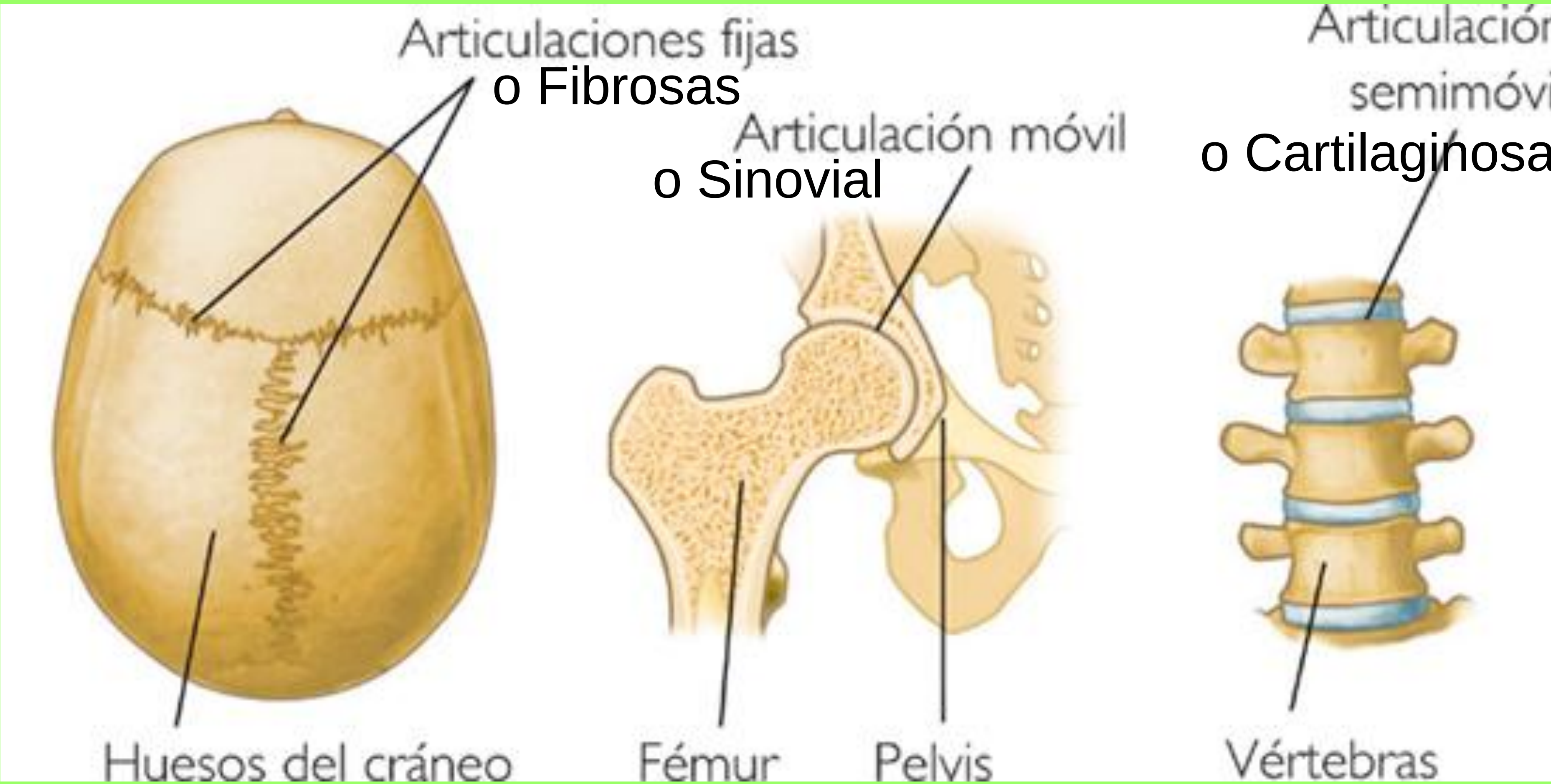




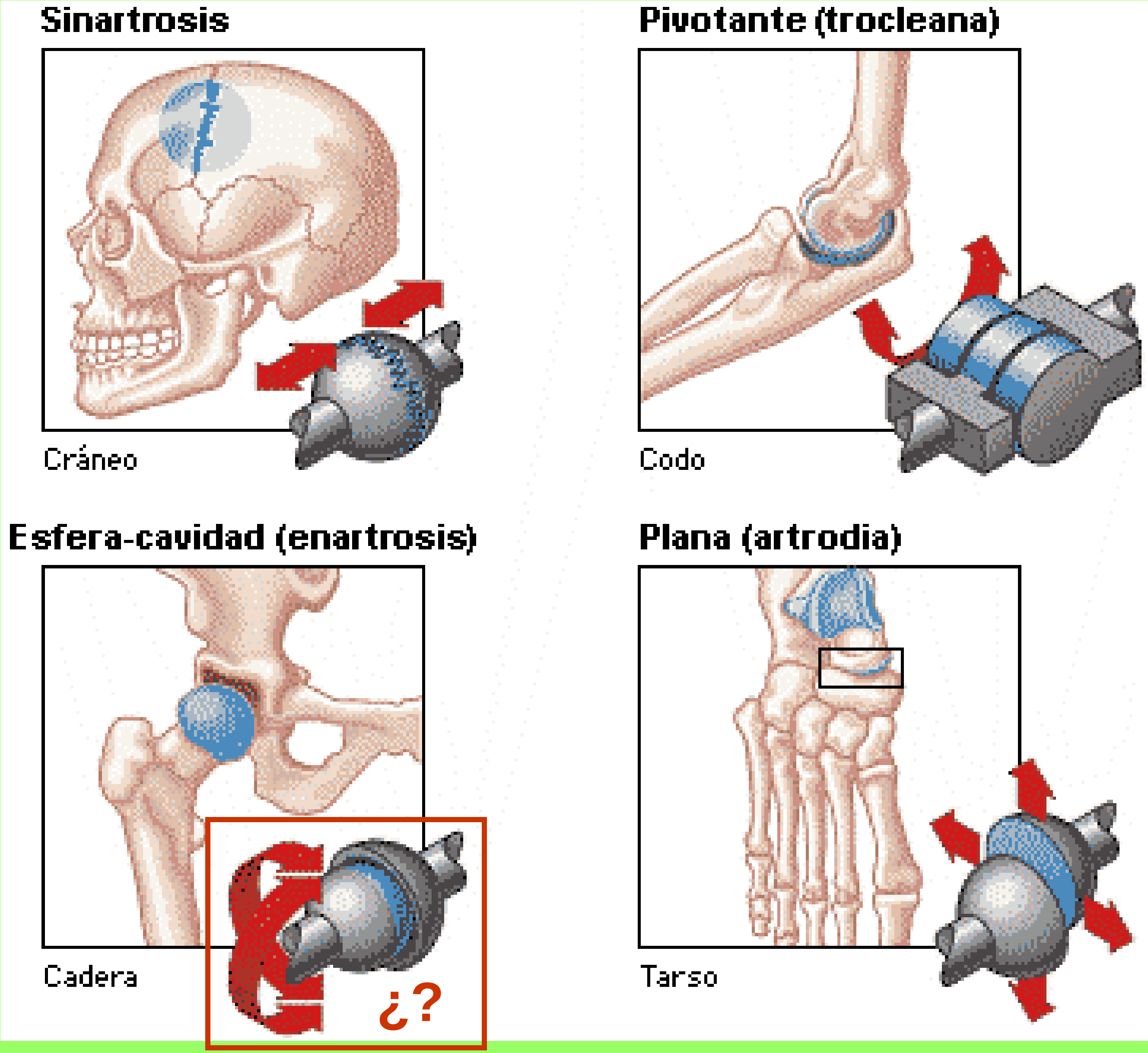
SISTEMA ESQUELETAL HUMANO Y ARTICULACIONES

Articulaciones:
Fibrosas, las que unen huesos con tejido conectivo fibroso, como en las suturas del cráneo. Son inamovibles.
Cartilaginosas, las que unen los huesos con cartílago, como la sínfisis del pubis y las vértebras. Tienen poca movilidad.
Sinoviales, son totalmente móviles y permiten todo tipo de movimientos y deslizamientos.

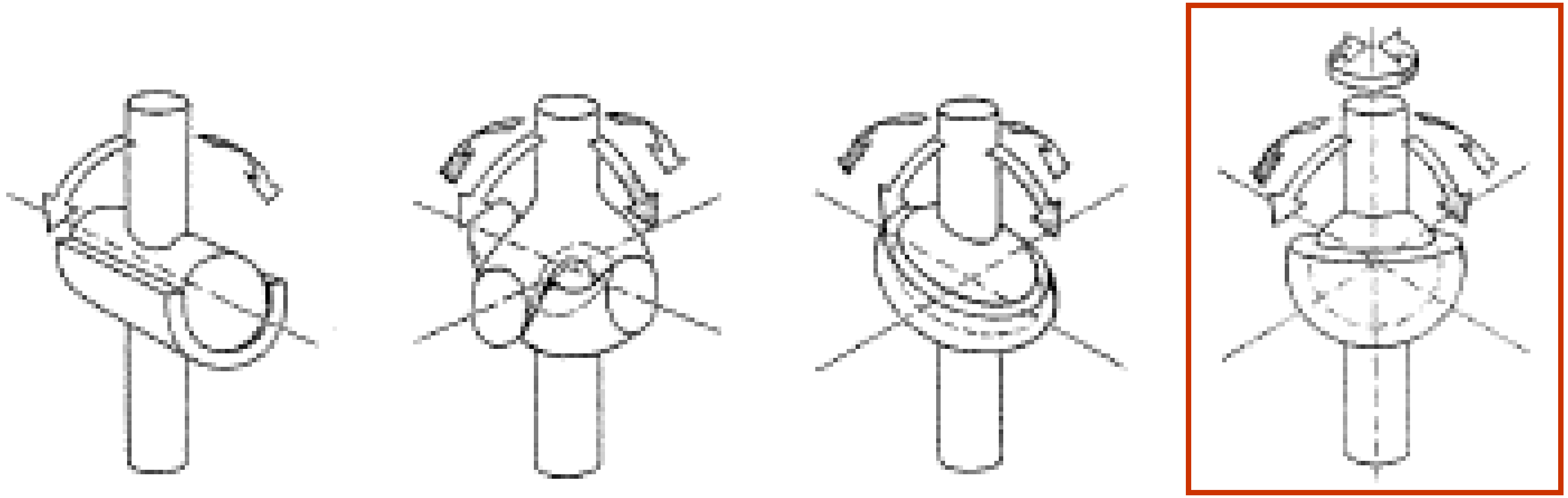
TIPOS DE ARTICULACIONES I



TIPOS DE ARTICULACIONES II



ARTICULACIONES 1D, 2D Y 3D



(a) Hinge joint (1D) | (b) Saddle joint (2D) | (c) Ellipsoidal joint (2D) | (d) Ball-and-socket joint (3D)

Bisagra | Silla de montar | Elipsoidal | Esfera y cavidad

Fig. 1.11. Rotation axes for four types of synovial joints are shown for each depicted rotation direction: **(a)** one axis for a hinge joint (1D joint), **(b)** two axes for a saddle joint (2D), **(c)** two axes for an ellipsoidal joint (2D), and **(d)** three axes for a ball-and-socket joint (3D). (From [54])

SEIS TIPOS DE ARTICULACIONES SINOVIALES

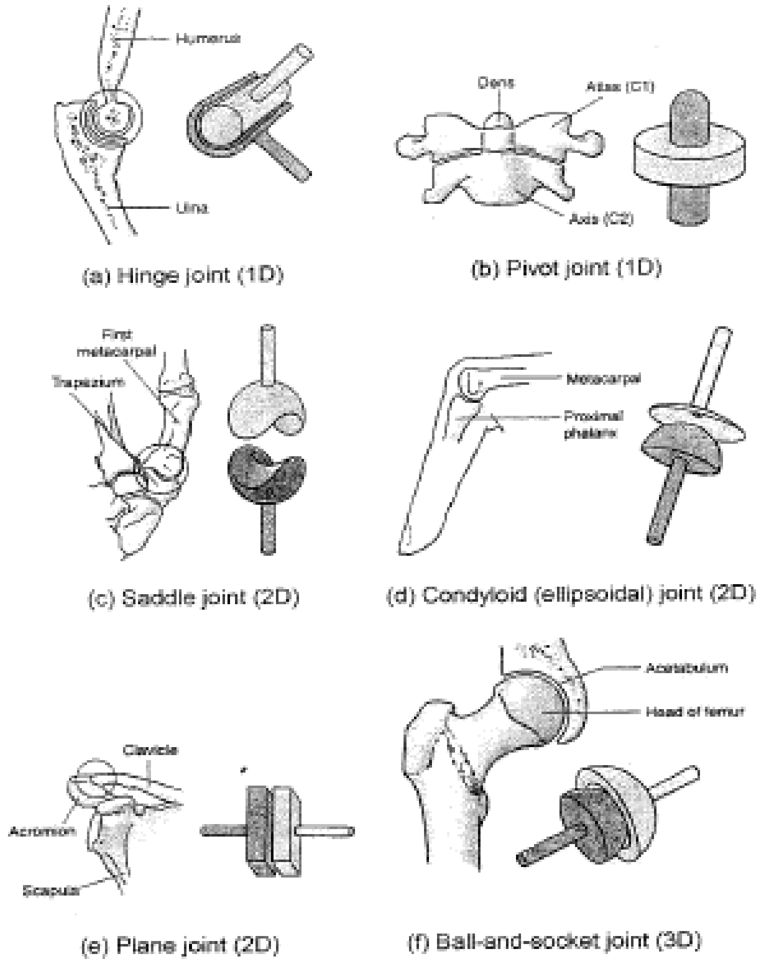
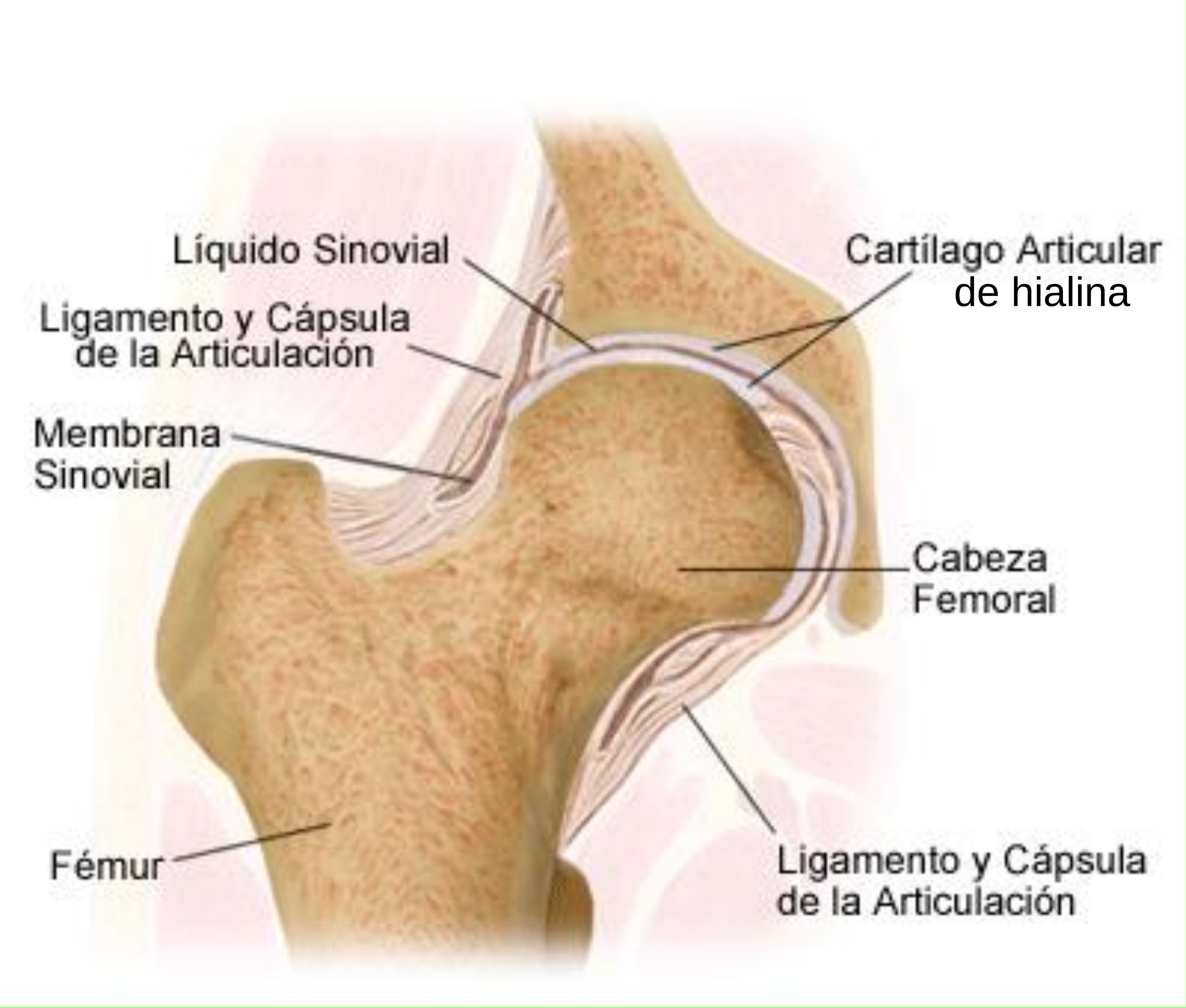
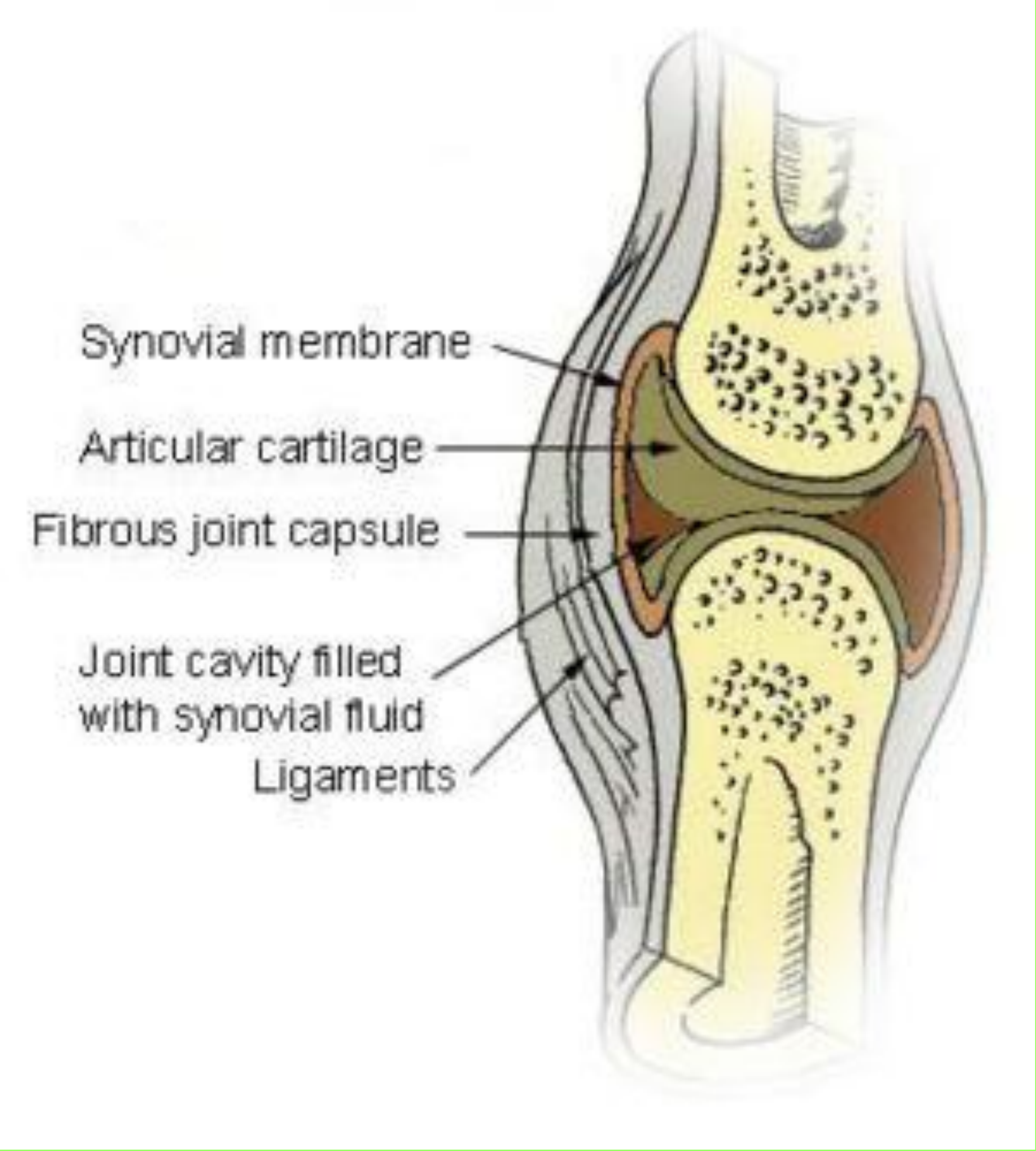


Fig. 1.4. Six types of synovial joints, including a: **(a)** hinge joint (1D joint), as in the elbow joint for flexion and extension, **(b)** pivot joint (1D joint), as in the atlantoaxial joint in the spinal cord for rotation, **(c)** saddle joint (2D), which is both concave and convex where the bones articulate, as in the joint between the first metacarpal and the trapezium in the hand, **(d)** condyloid or ellipsoidal joint (2D), as in the metacarpophalangeal (knuckle) joint between the metacarpal and proximal phalanx for flexion and extension, abduction and adduction, and circumduction, **(e)** plane joint (2D), as in the acromioclavicular joint in the shoulder for gliding or sliding, and **(f)** ball-and-socket joint (3D), as in the hip joint (and the shoulder joint) for flexion and extension, abduction and adduction, and medial and lateral rotation. See Figs. 1.9 and 1.10 for definitions of the terms describing the types of motion about joints and the diagrams in Fig. 1.11 for more information about synovial joints. (From [49]. Used with permission)

ARTICULACION DE LA CADERA



ARTICULACION SINOVIAL



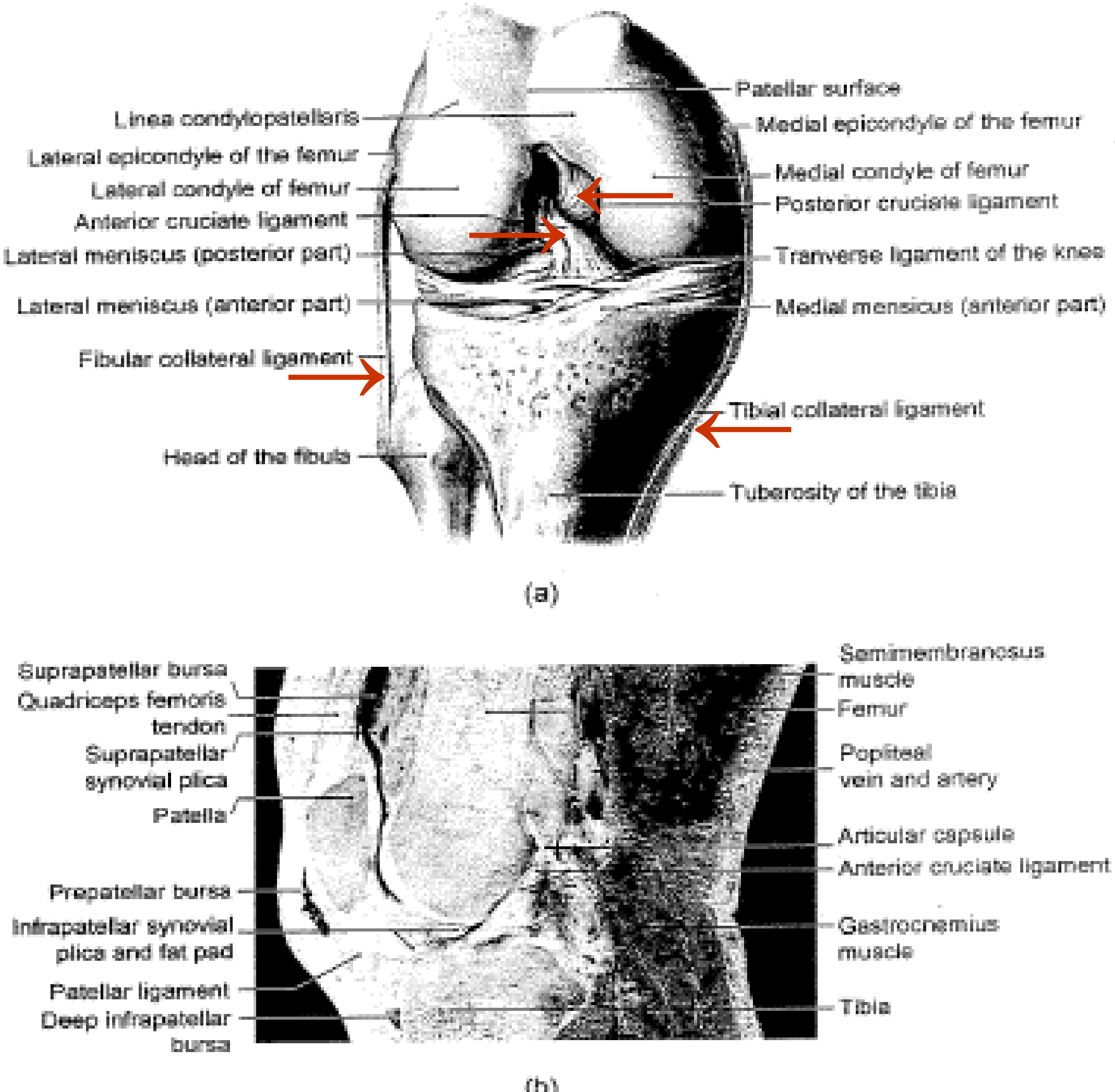


Fig. 1.3. The right knee synovial joint, with (a) anterior view with the kneecap (patella) removed and (b) in sagittal section (photo). Also see Fig. 3.2c. (From [59])

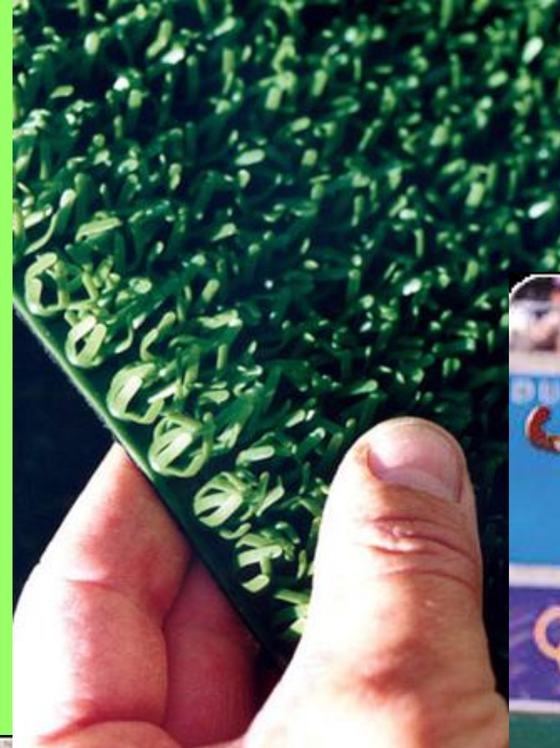
RODILLA DERECHA

COEFICIENTES DE ROZAMIENTO

Table 3.4. Static and kinetic (when noted) coefficient of friction, μ. (Using data from [109, 110, 159])

common objects and the body	
rubber (tire) on dry (wet) concrete road, static	1.0
brake material on cast ion, dry; static	0.4
brake material on cast ion, with mineral oil; static	0.1
graphite on steel, static	0.1
steel on unlubricated steel	0.7
steel on lubricated steel or ice	0.15
teflon on teflon (or steel)	0.04
ice on ice	0.1
ice on ice, 4 m/s, 0°C, kinetic	0.02
wood on wood	0.25–0.50
articular cartilage in the human knee, kinetic	0.005–0.02
articular cartilage in the human hip, kinetic	0.01–0.04
athletic equipment (kinetic)	
skates on ice	0.003–0.007
skis on snow	0.05–0.20
tennis balls on wood	0.25
basketball shoes on clean (dusty) wooden floor	1.0–1.2 (0.3–0.6)
cleated shoes on astroturf	1.2–1.7
jogging shoes on felt carpet, clay, asphalt	0.9–1.1, 0.3–0.5, 0.6–0.8

CARPETAS ASTRO TURF



CALZADO DEPORTIVO

Golf

Fútbol

Ciclismo

Rugby

Montaña

Béisbol

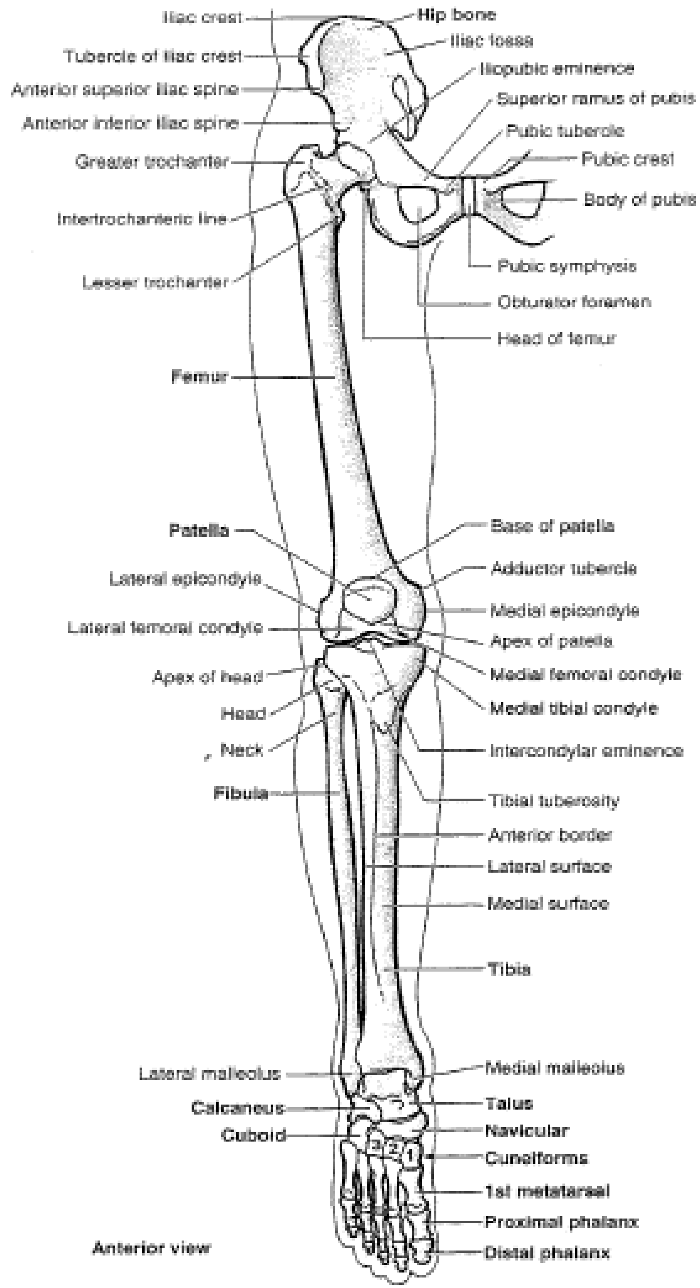


Fig. 2.14. Bones of the leg and hip anterior view, with names of bones in bold. (From [79]. Used with permission)

HUESOS DE

LA PIERNA

Y DE LA

CADERA

TRES ARTICULACIONES Y SEIS GRADOS DE LIBERTAD

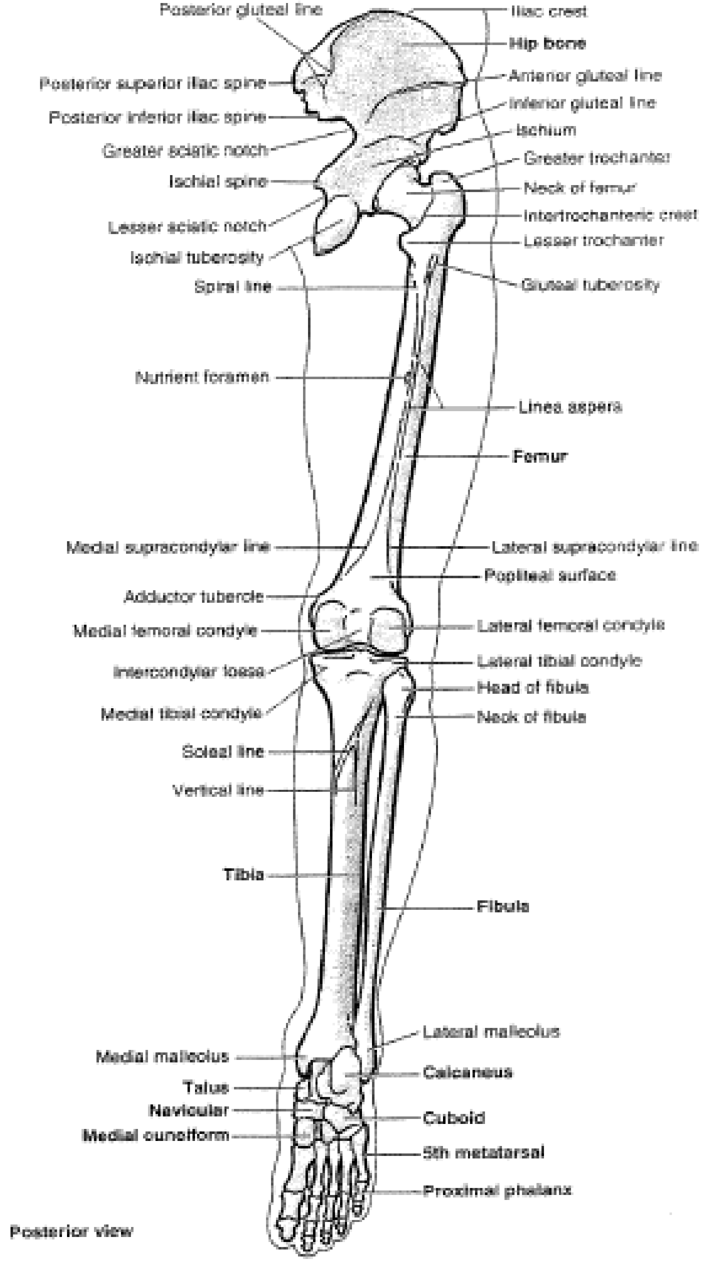


Fig. 2.15. Bones of the leg and hip, posterior view, with names of bones in bold. (From [79]. Used with permission)

HUESOS DE

LA PIERNA

Y DE LA

CADERA

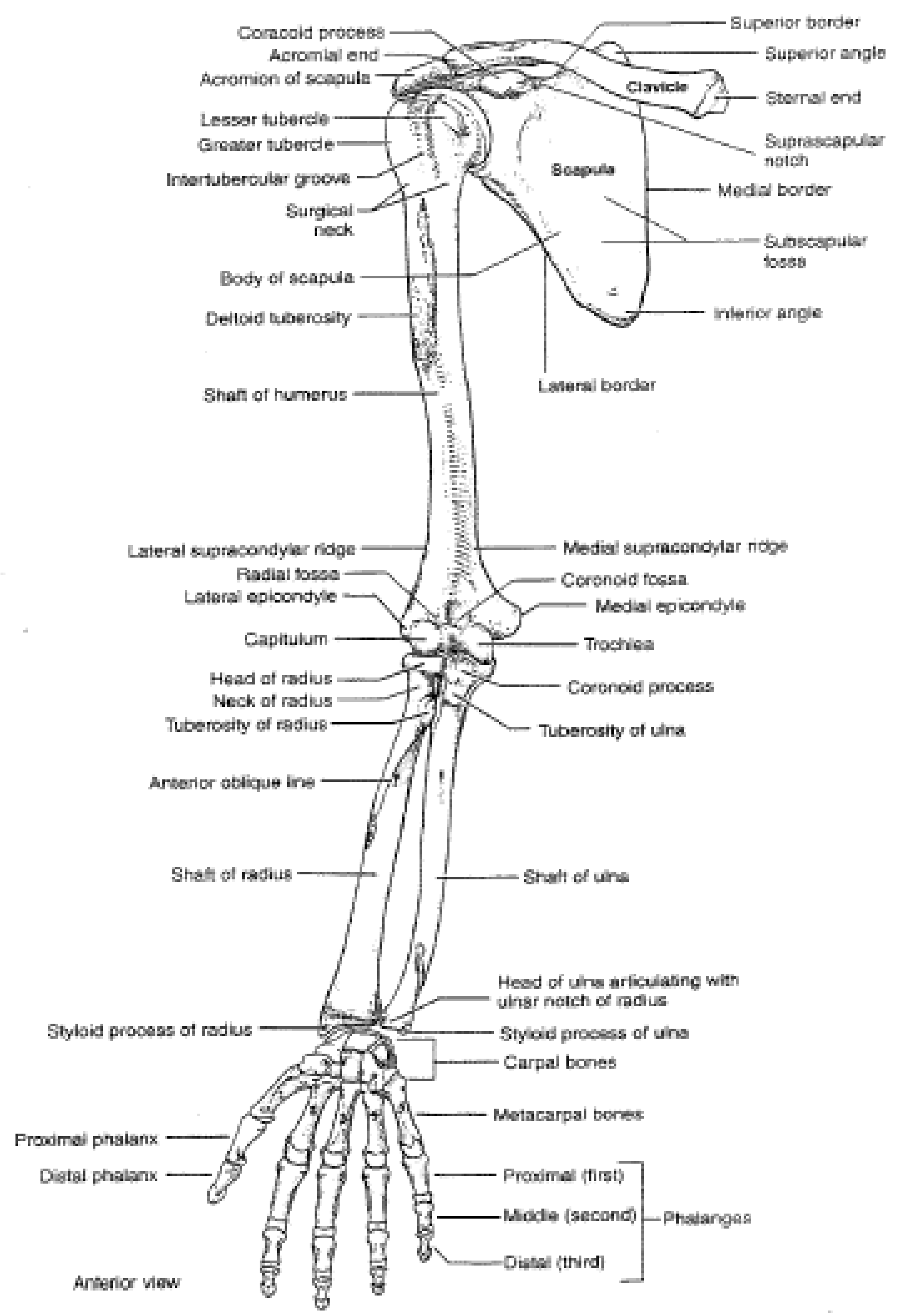


Fig. 2.7. Bones of the arm, anterior view. (From [78]. Used with permission)

HUESOS

DEL

BRAZO

TRES ARTICULACIONES Y SIETE GRADOS DE LIBERTAD

HUESOS

DEL

BRAZO

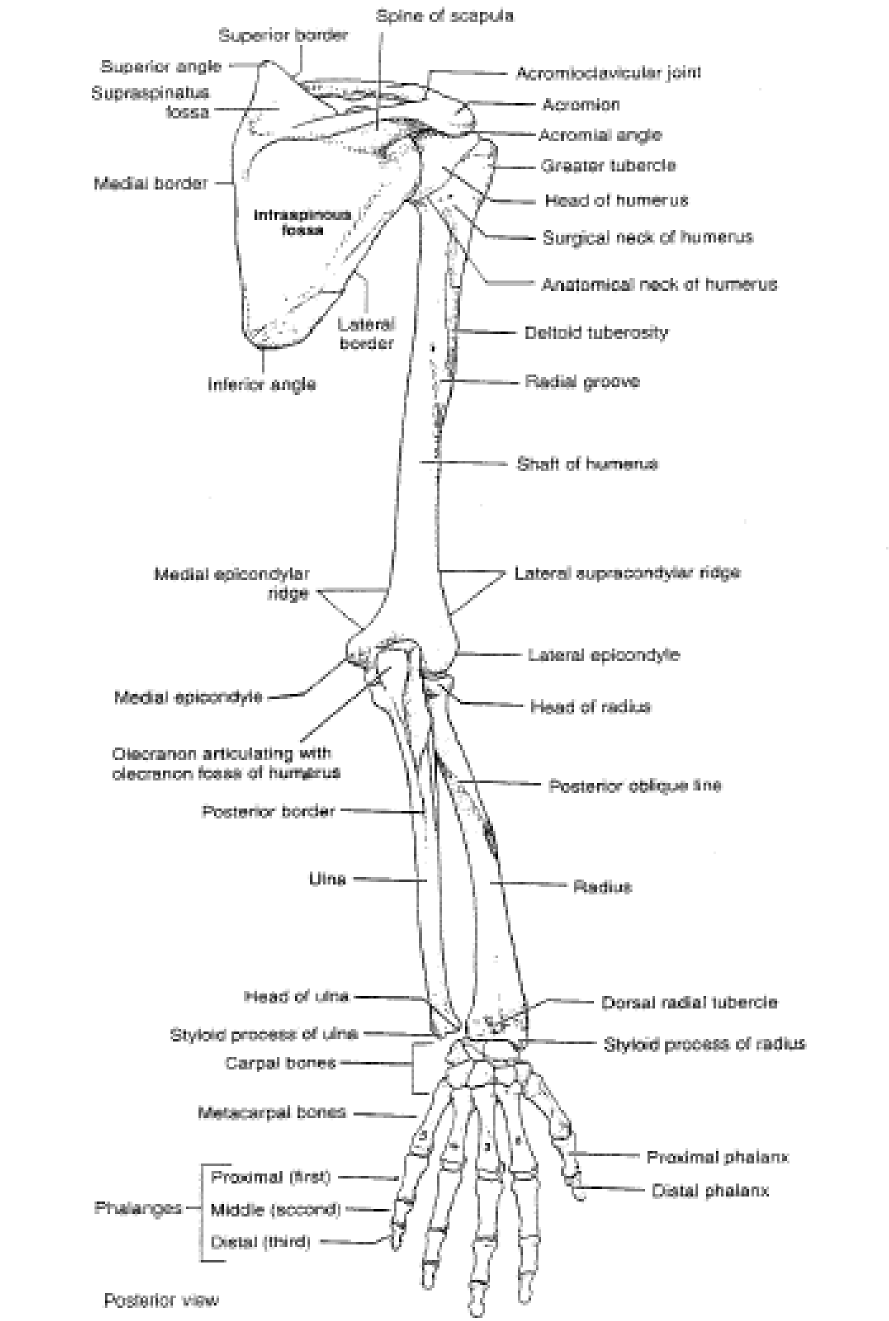
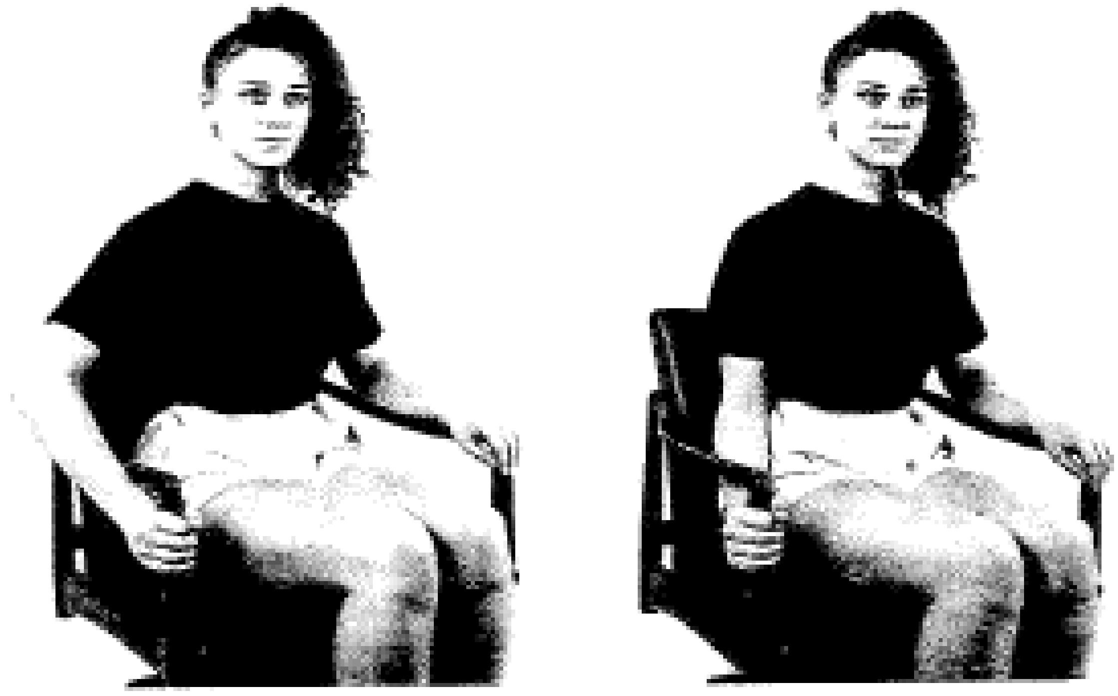


Fig. 2.8. Bones of the arm, posterior view. (From [78]. Used with permission)

SEIS GRADOS DE LIBERTAD DE LA MANO



(a) (b)

Fig. 1.5. Nonunique way of positioning the right arm. This is demonstrated by grasping the armrest while sitting, with the six coordinates of the hand (three for position and three for angle) being the same in both arm positions. This is possible because the arm can use its seven degrees of freedom to determine these six coordinates. (From [32]. Copyright 1992 Columbia University Press. Reprinted with the permission of the press)

GRADOS DE LIBERTAD DE LOS DEDOS DE LA MANO

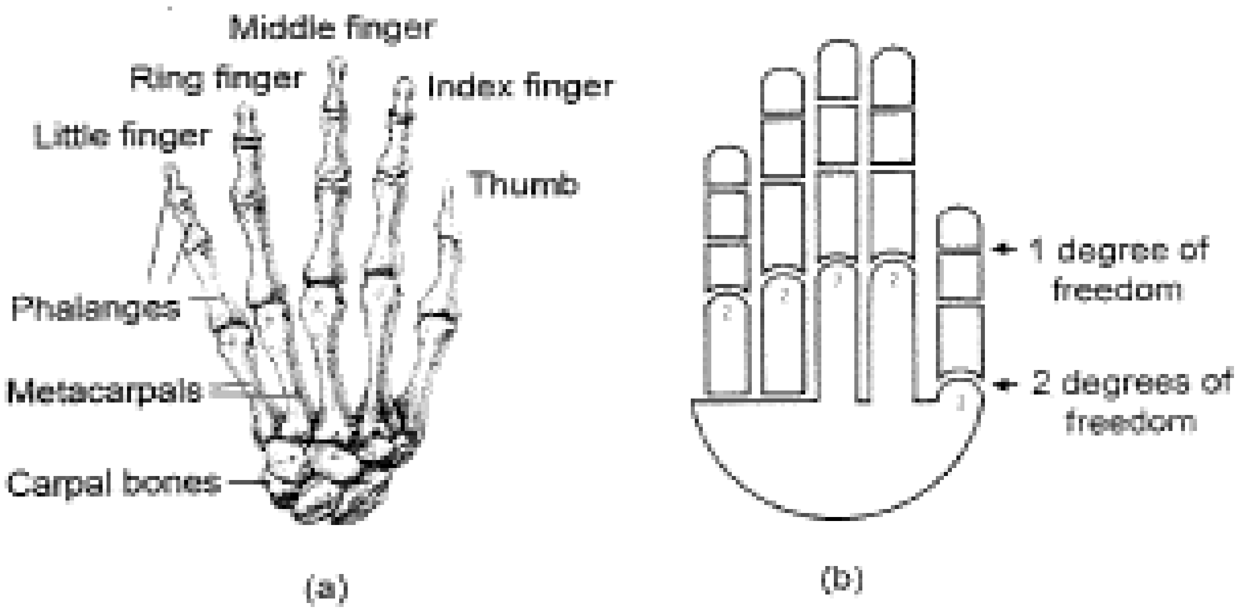


Fig. 1.6. **(a)** Anatomy of the hand and **(b)** the degrees of freedom of the hand and fingers, with joints (spaces) having one (spaces with flat terminations) or two (curved terminations, with a "2" below the joint) degrees of freedom. (From [32]. Copyright 1992 Columbia University Press. Reprinted with the permission of the press)

MOVIMIENTOS DE LA MANO

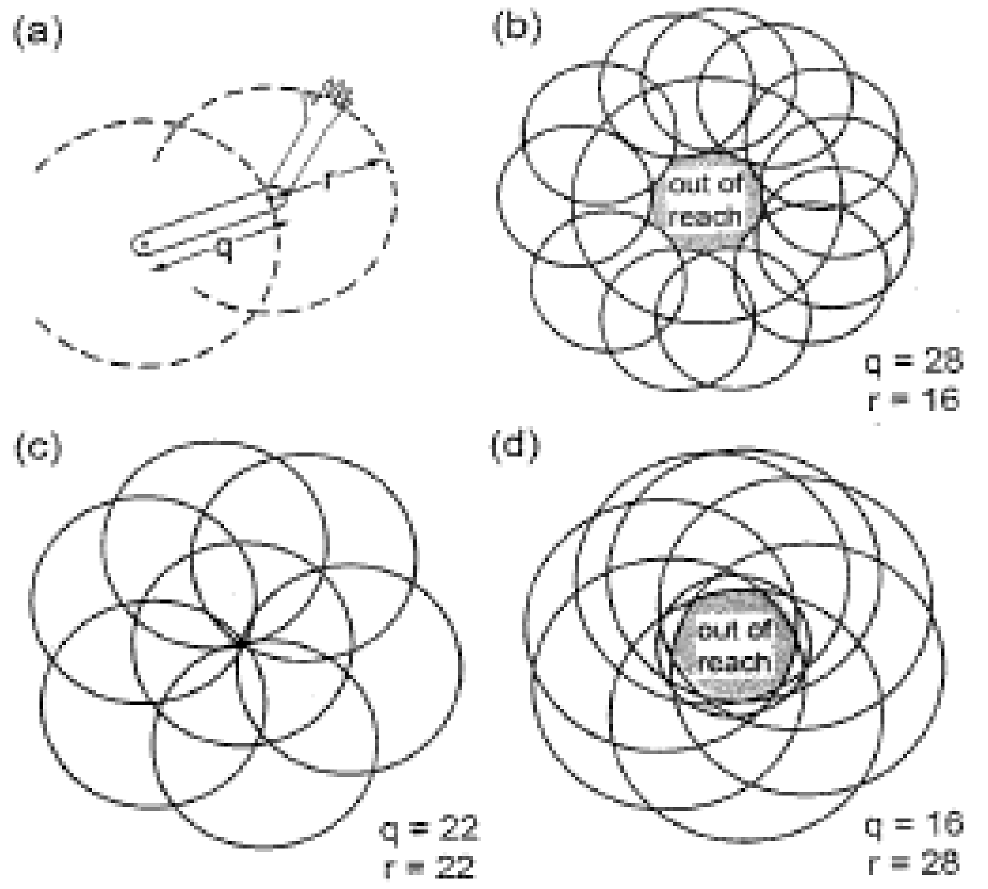


Fig. 1.7. Range of hand motion in two dimensions for different lengths of the upper and lower arms. (From [32]. Copyright 1992 Columbia University Press. Reprinted with the permission of the press)

GRANDES MUSCULOS ESQUELETALES I

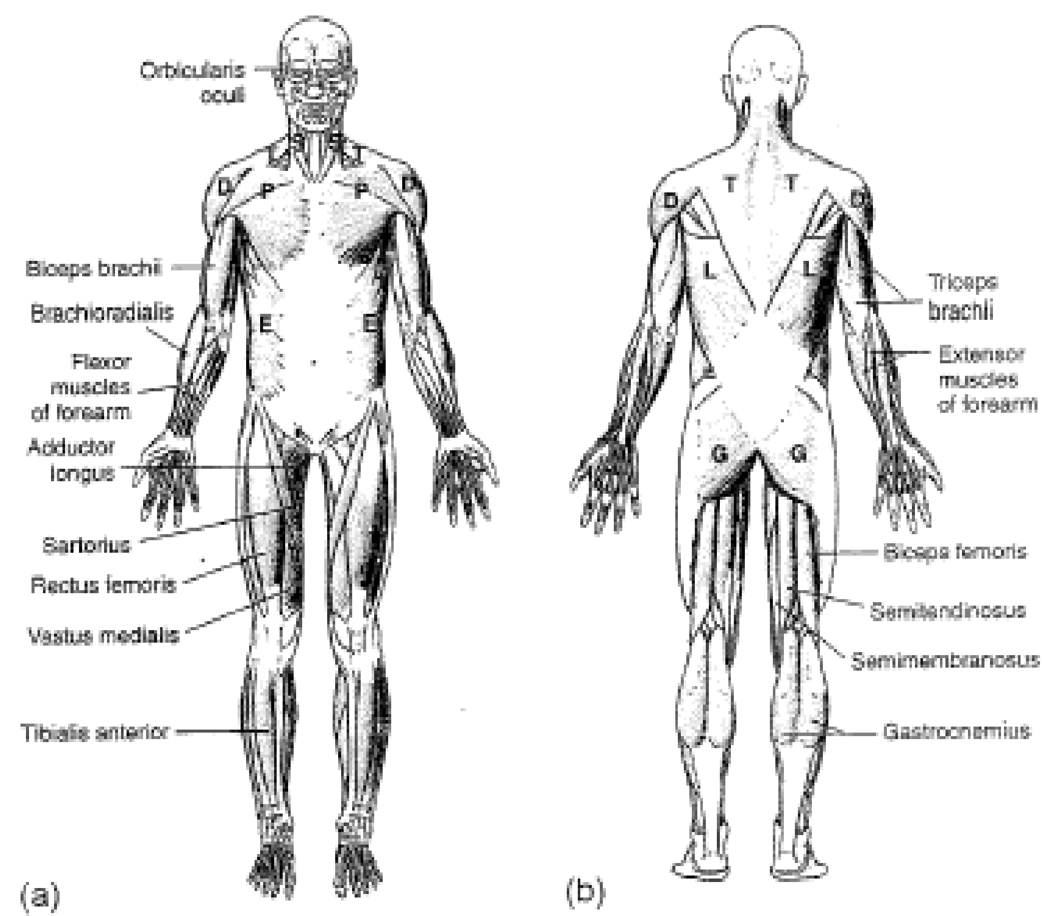
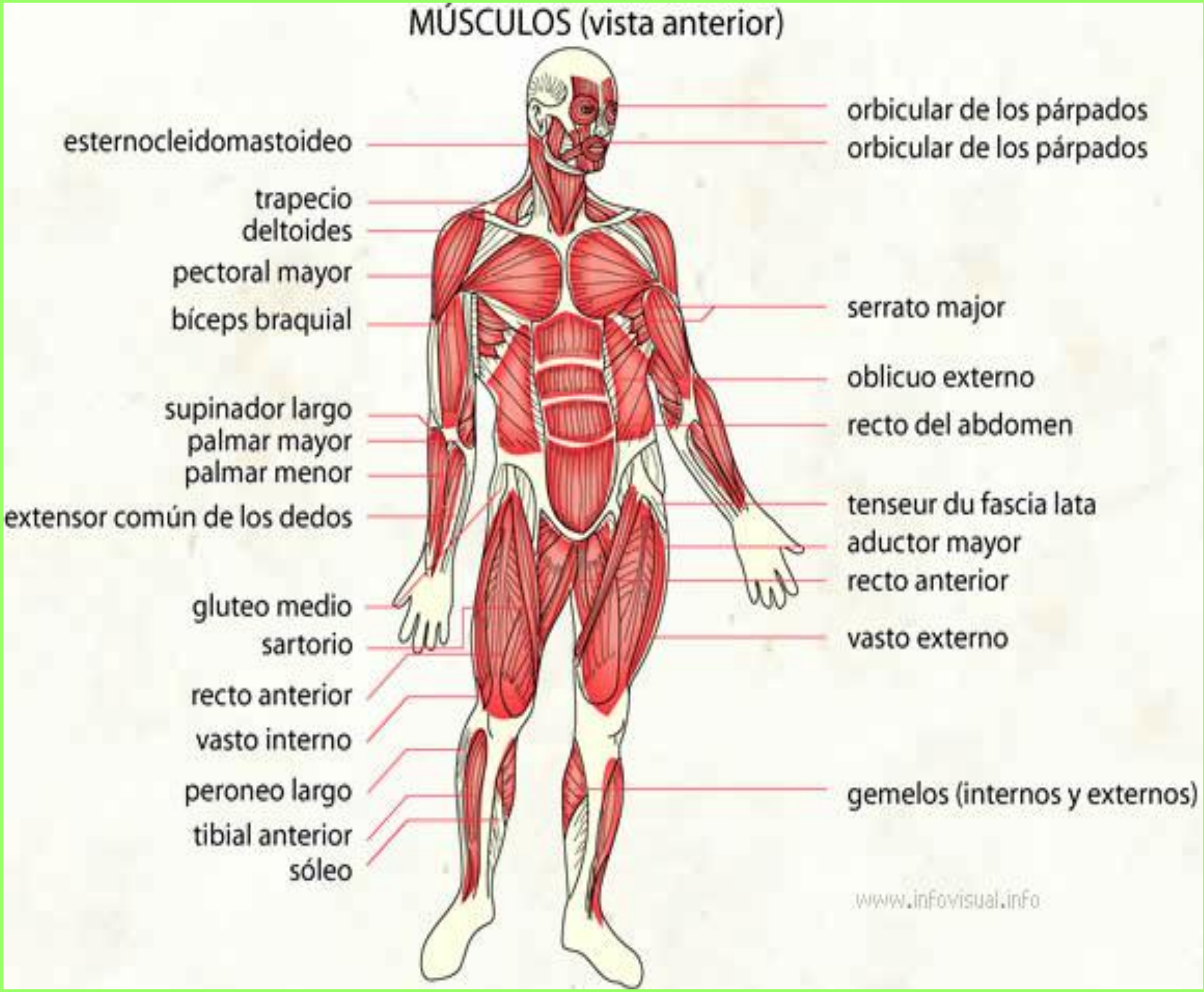
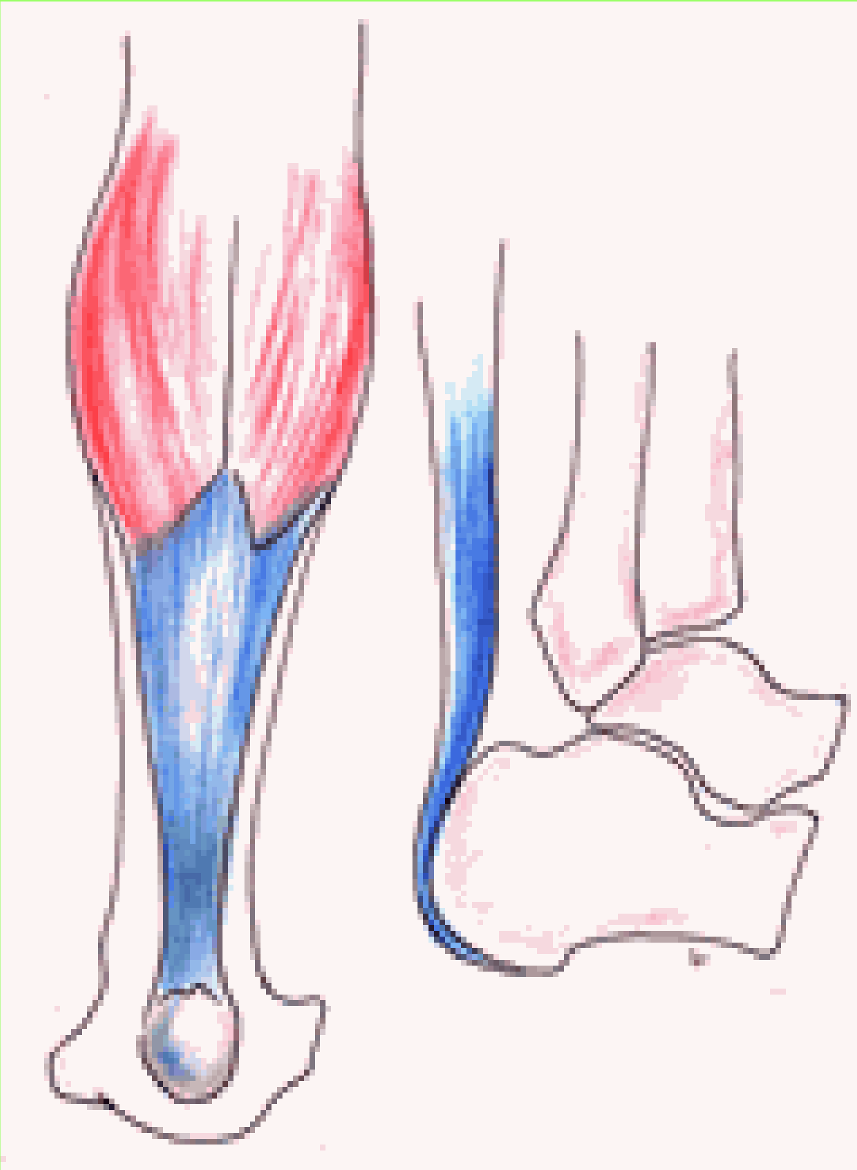


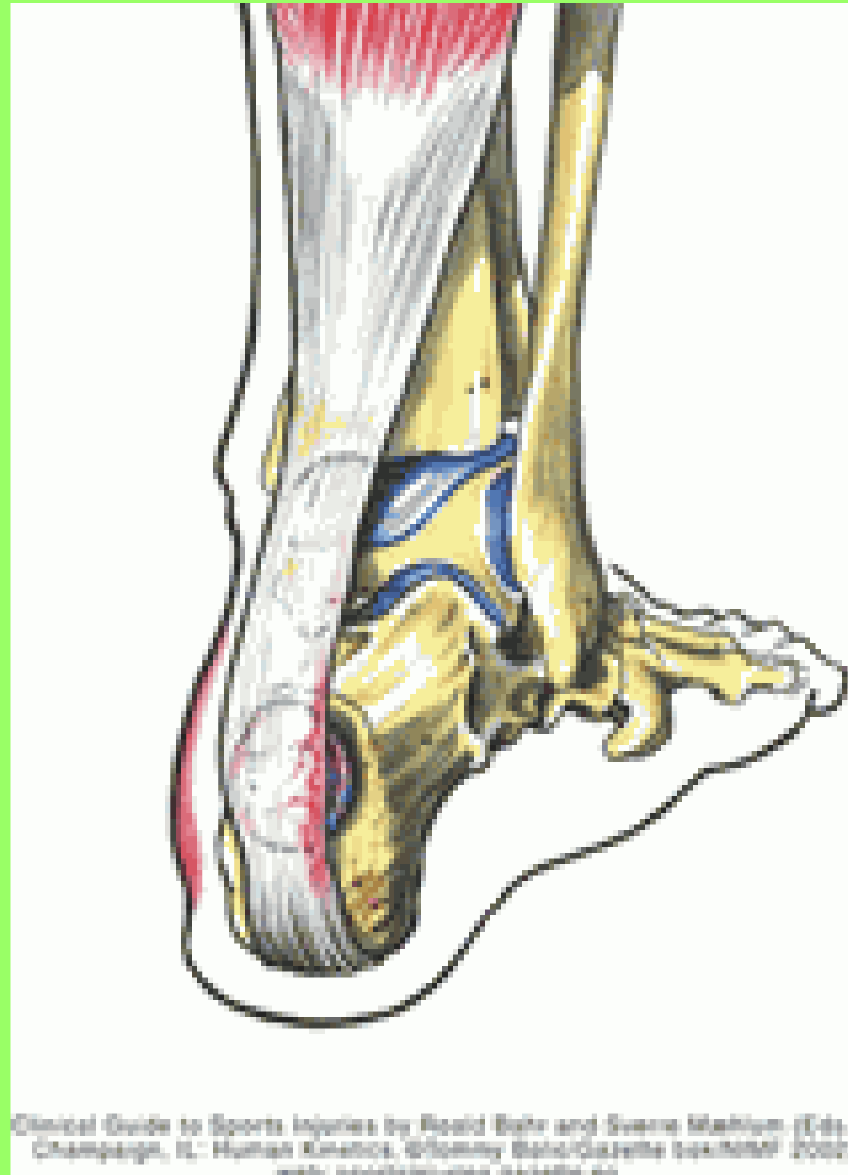
Fig. 1.8. **(a)** Anterior and **(b)** posterior views of some of the larger skeletal muscles in the body. Several muscles are labeled: S, sternocleidomastoid; T, trapezius; D, deltoid;, P, pectoralis major; E, external oblique; L, latissimus dorsi; G, gluteus maximus. In **(b)**, the broad-banded tendon extending from the gastrocnemius and soleus (deep to the gastrocnemius, not shown) muscles to the ankle (calcaneus) is the calcaneal (or Achilles) tendon. (From [49]. Used with permission)

GRANDES MUSCULOS ESQUELETALES II



TENDON DE AQUILES





MOVIMIENTOS ANTAGONICOS

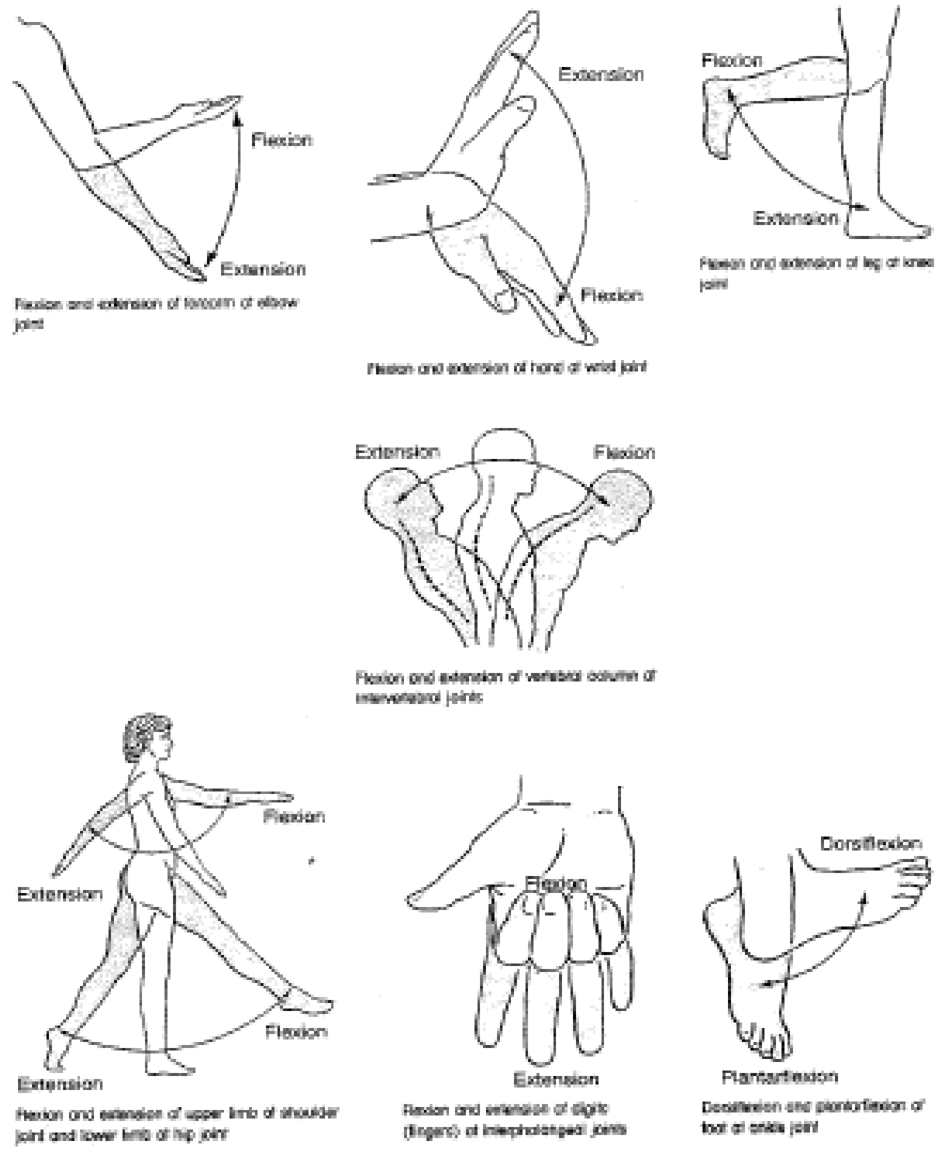


Fig. 1.9. Several antagonistic motions allowed by synovial joints. See other motions in Fig. 1.10. (From [49]. Used with permission)

MOVIMIENTOS ANTAGONICOS

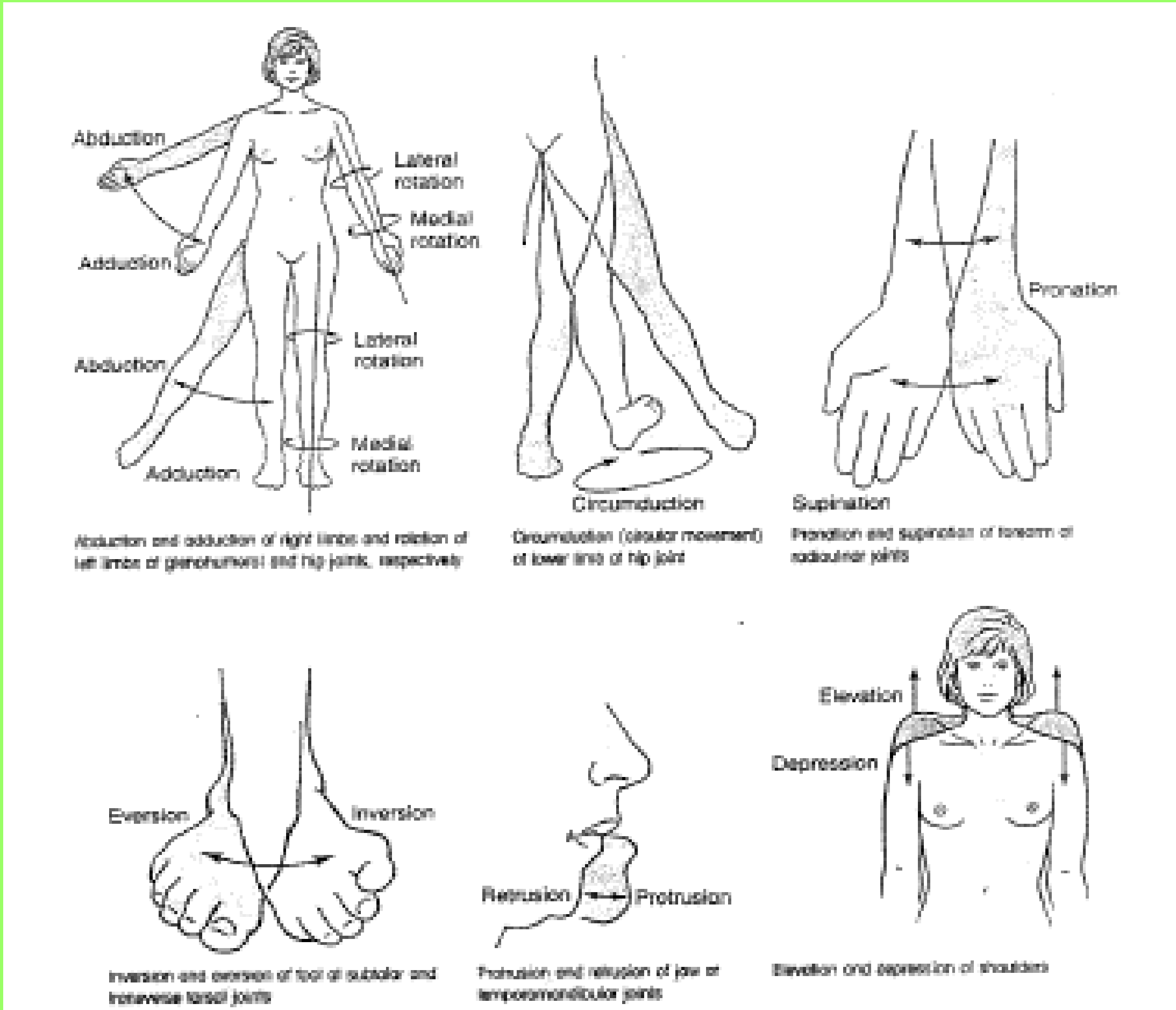


Fig. 1.10. More antagonistic motions allowed by synovial joints. See other motions in Fig. 1.9. (From [49]. Used with permission)

MUSCULOS ANTAGONICOS DEL BRAZO Y SUS MOVIMIENTOS

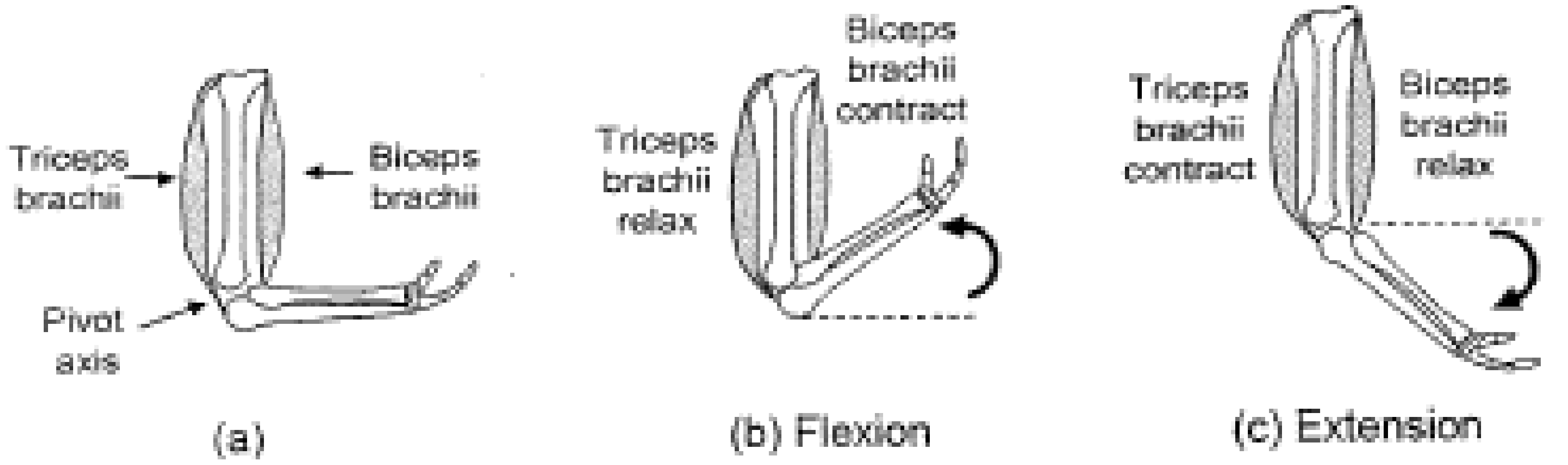


Fig. 1.12. Opposing motions of the lower arm with antagonist muscles, with flexion by contraction of the biceps brachii and extension by the contraction of the triceps brachii. The axis of rotation is seen in Fig. 1.11a

ROTACIONES DEL OJO DERECHO

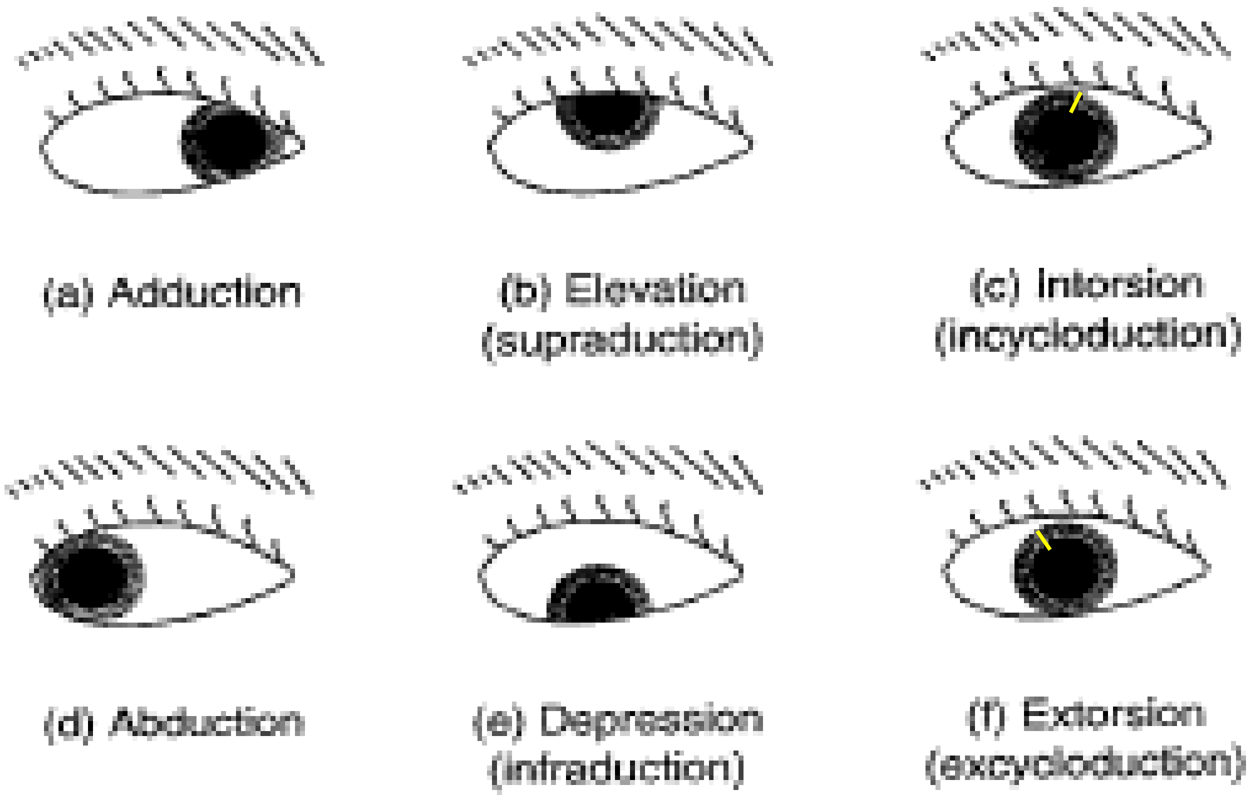


Fig. 1.13. Rotations of the right eye. A yellow line has been added across the iris to help view the rotations. (Based on [60])

MUSCULOS OCULARES I

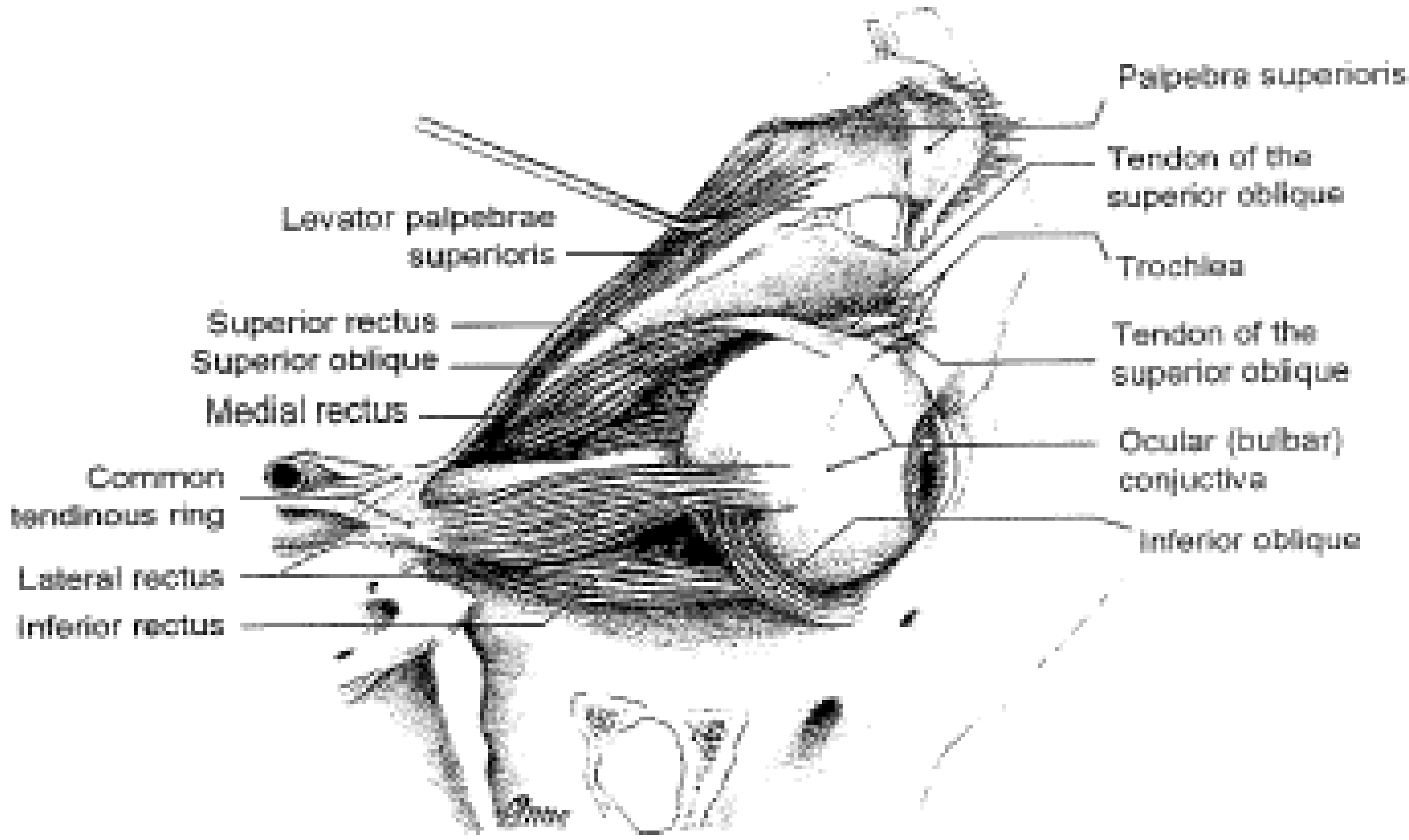
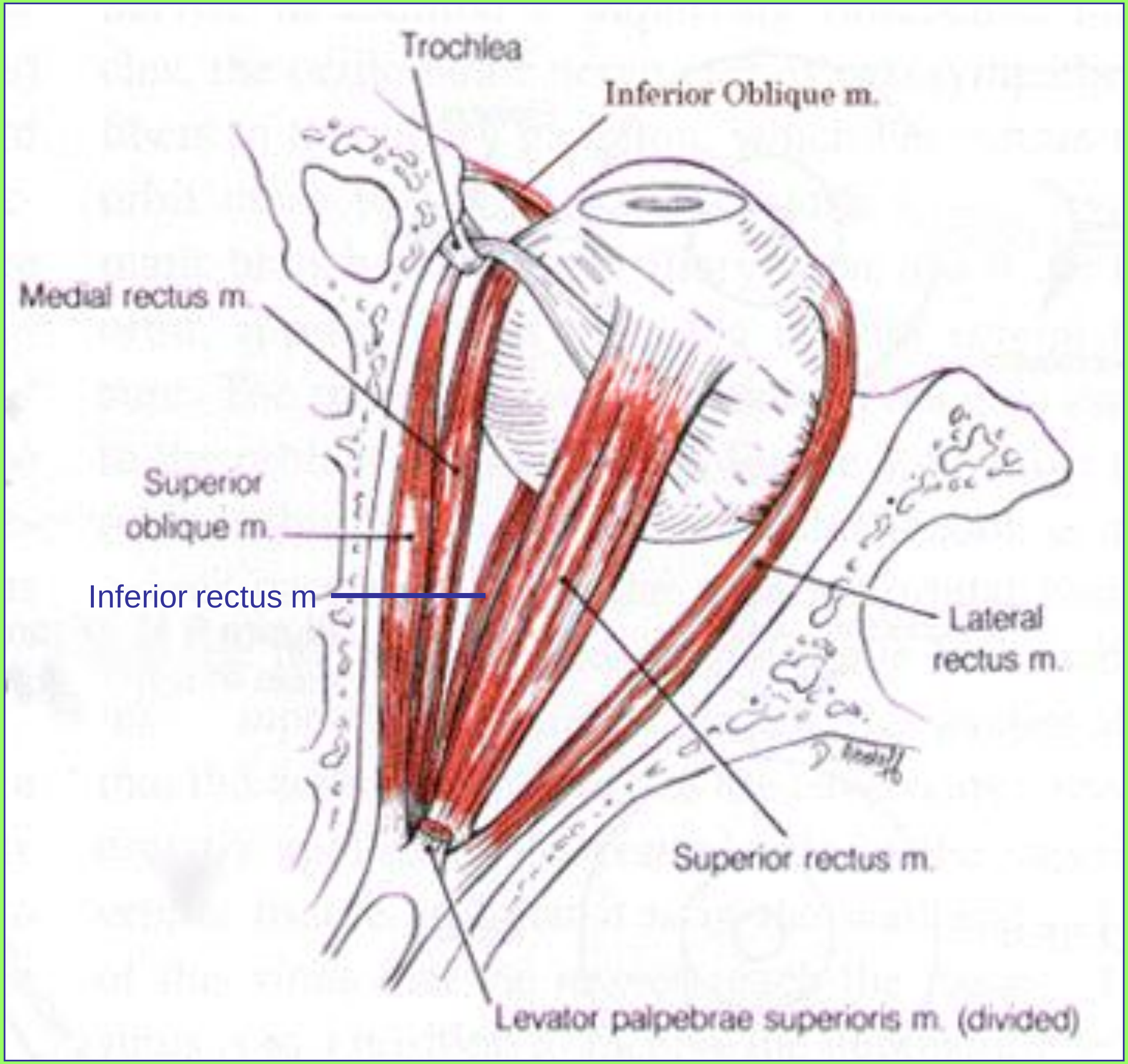
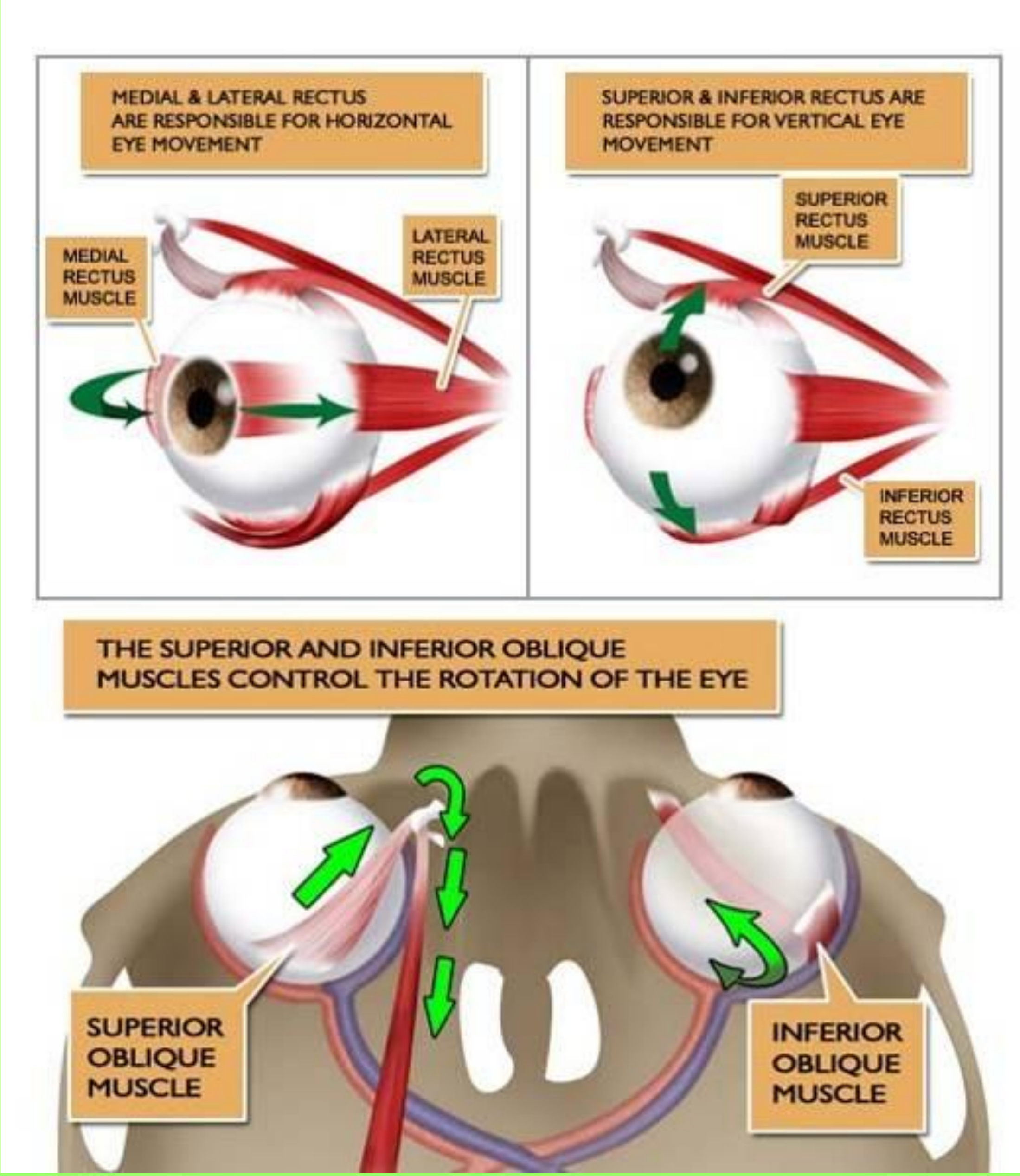


Fig. 1.14. Ocular muscles, with the eyelid (palpebra) pulled up as shown. The tendon of the superior oblique muscle (marked in two regions) passes through the trochlea loop. (From [59])

MUSCULOS OCULARES II



MOVIMIENTOS DEL OJO HUMANO



FUNCIONES DE LOS MUSCULOS OCULARES

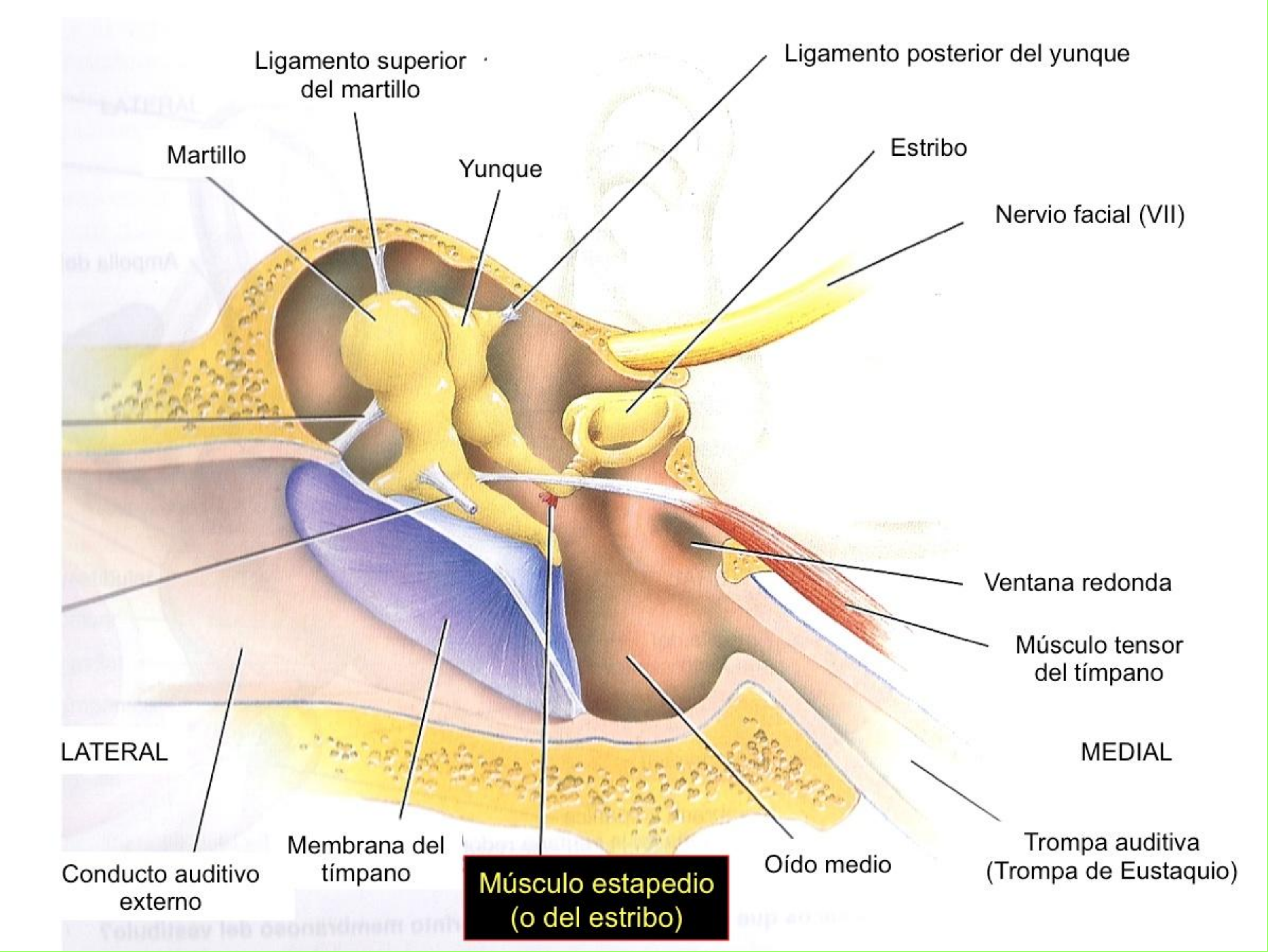
Table 1.3. Ocular muscle functions. (Based on [60])

muscle	primary action	secondary action
lateral rectus	abduction	none
medial rectus	adduction	none
superior rectus	elevation	adduction, intorsion
inferior rectus	depression	abduction, extorsion
superior oblique	depression	intorsion, abduction
inferior oblique	elevation	extorsion, abduction

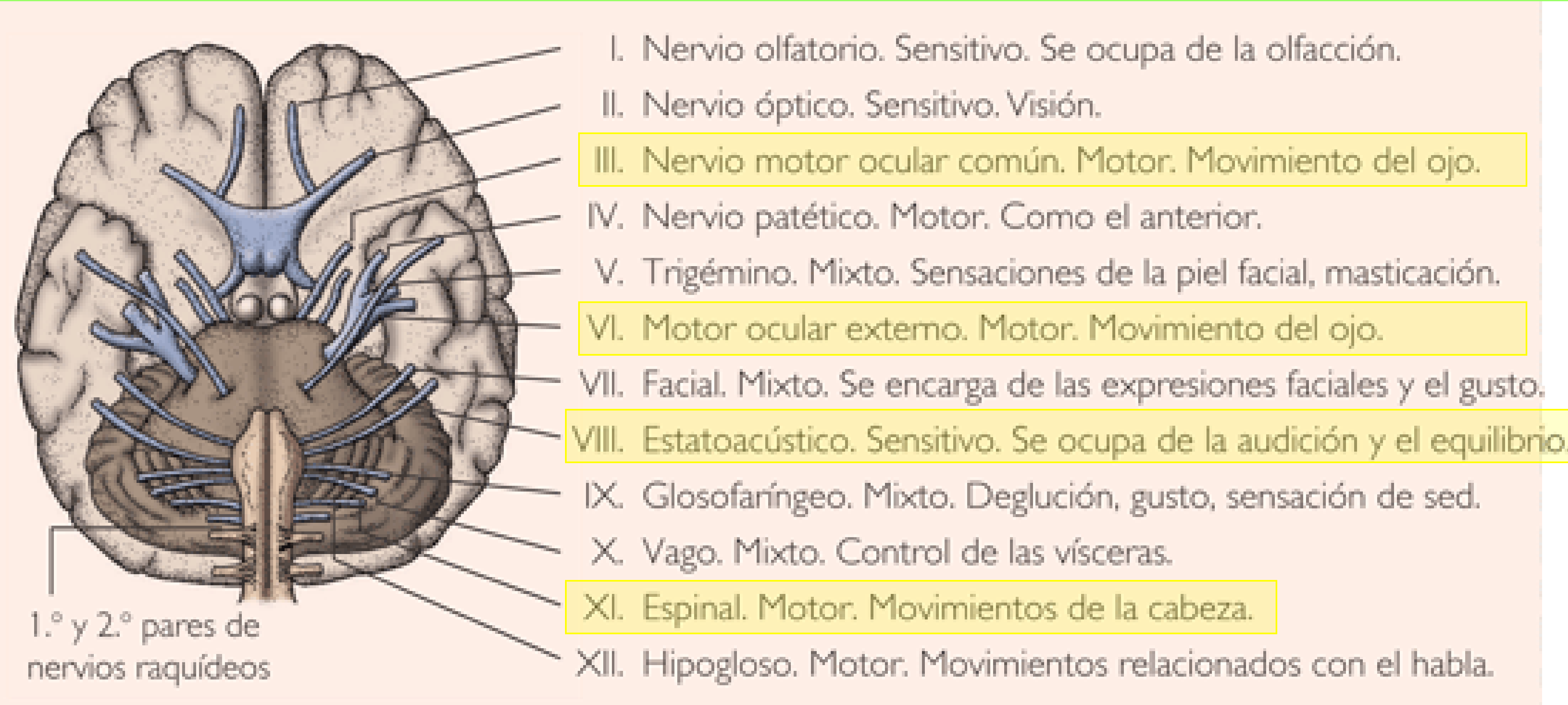
Table 1.4. Muscle combinations of both eyes for gaze directions. (Based on [60])

direction of gaze	right eye muscle	left eye muscle
eyes up, right	superior rectus	inferior oblique
eyes right	lateral rectus	medial rectus
eyes down, right	inferior rectus	superior oblique
eyes down, left	superior oblique	inferior rectus
eyes left	medial rectus	lateral rectus
eyes up, left	inferior oblique	superior rectus

OIDO


Ligamento superior del martillo
Ligamento posterior del yunque
Martillo
Yunque
Estribo
Nervio facial (VII)
Ventana redonda
Músculo tensor del tímpano
LATERAL
MEDIAL
Conducto auditivo externo
Membrana del tímpano
Músculo estapedio (o del estribo)
Oído medio
Trompa auditiva (Trompa de Eustaquio)

PARES CRANEALES



BIOFISICA

CAPITULO 1

El Cuerpo Humano Estándar

Table 1.5. A description of the "Standard Man". (Using data from [37, 44]) ← 1974

1999

age	30 yr
height	1.72 m (5 ft 8 in)
mass	70 kg
weight	690 N (154 lb)
surface area	1.85 m^2
body core temperature	37.0° C
body skin temperature	34.0° C
heat capacity	0.83 kcal/kg-°C (3.5 kJ/kg-°C)
basal metabolic rate	70 kcal/h (1,680 kcal/day, 38 kcal/m^2-h, 44 W/m^2)
body fat	15%
subcutaneous fat layer	5 mm
body fluids volume	51 L
body fluids composition	53% intracellular; 40% interstitial, lymph; 7% plasma
heart rate	65 beats/min
blood volume	5.2 L
blood hematocrit	0.43
cardiac output (at rest)	5.0 L/min
cardiac output (in general)	3.0 + 8 × O_2 consumption (in L/min) L/min
systolic blood pressure	120 mmHg (16.0 kPa)
diastolic blood pressure	80 mmHg (10.7 kPa)
breathing rate	15/min
O_2 consumption	0.26 L/min
CO_2 production	0.21 L/min
total lung capacity	6.0 L
vital capacity	4.8 L
tidal volume	0.5 L
lung dead space	0.15 L
lung mass transfer area	90 m^2
mechanical work efficiency	0–25%

There are wide variations about these typical values for body parameters. Also, these values are different for different regions; the ones in the table typify American males in the mid-1970s. Values for women are different than for men; for example, their typical heights and weights are lower and their percentage of body fat is higher.

DESCRIPCION DEL HOMBRE ESTANDARD

$44 W/m^2 \times 1,85\ m^2 = 81,40\ W$

$37,84\ kcal/m^2h = 43,98\ W/m^2 \times 1,85\ m^2 = 81,36\ W$

Diferencia: 0,05 %

No se menciona la densidad promedio

1 kcal = 4184 J

EL HOMBRE ESTANDARD LINEAL

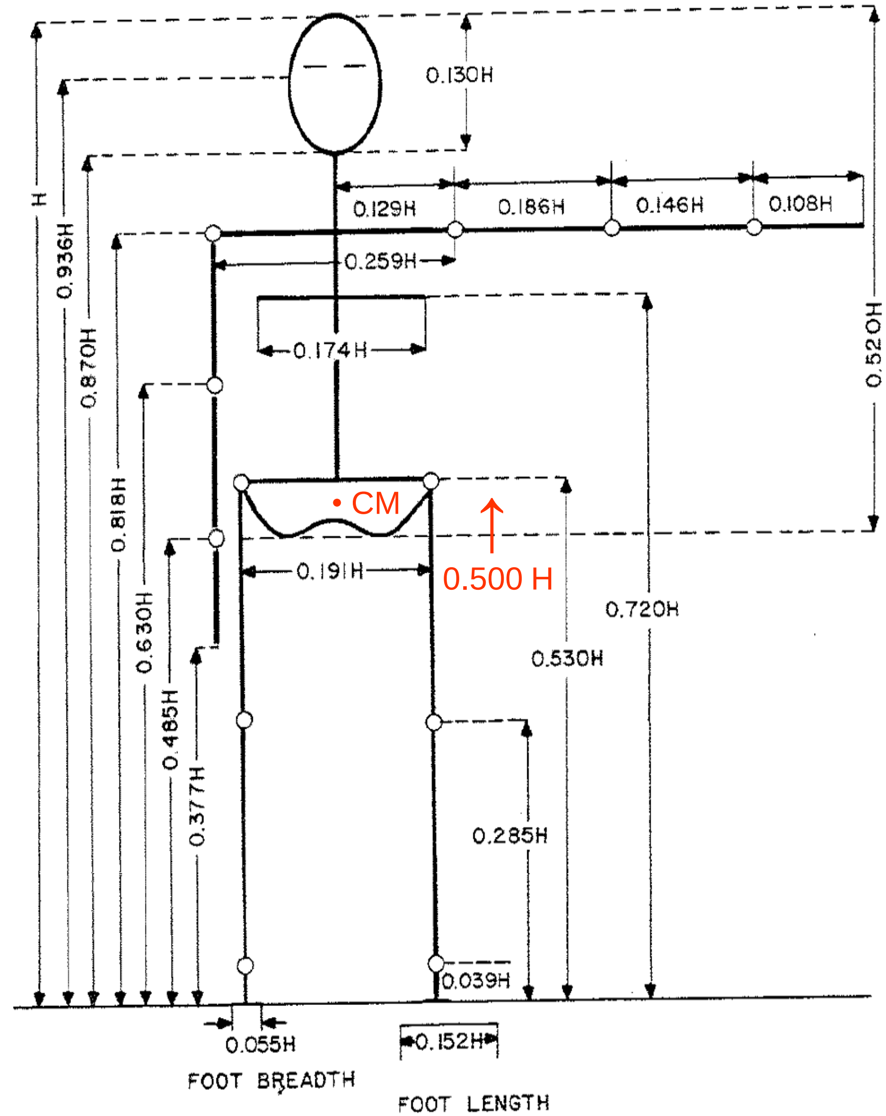


Fig. 1.15. Body segments length, relative to body height *H*. (From [38], as from [53]. Reprinted with permission of Wiley)

LONGITUDES DE SEGMENTOS

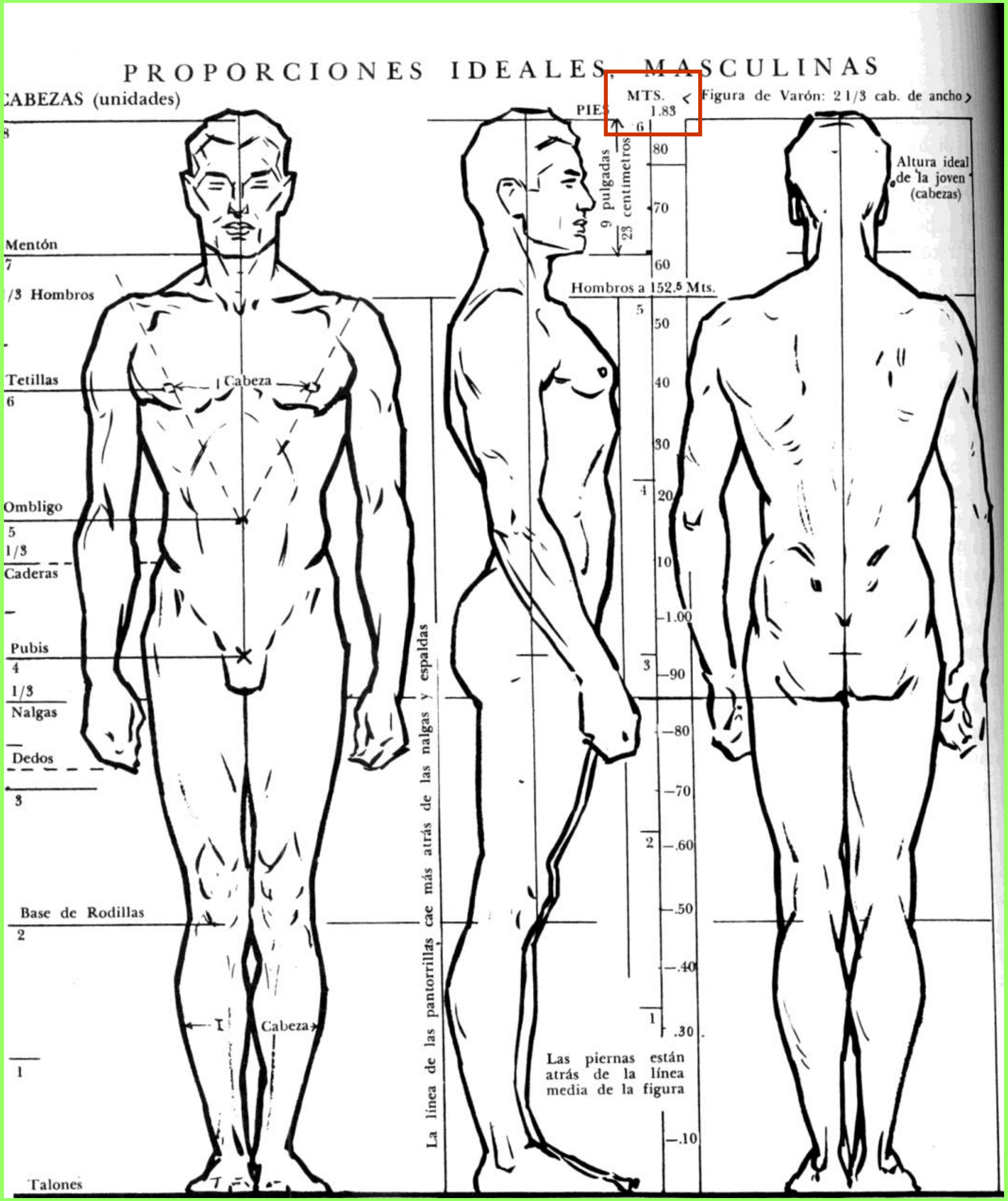
Table 1.6. Body segment lengths. Also see Fig. 1.15. (Using data from [63])

segment	segment length[a] / body height H
head height	0.130
neck height	0.052
shoulder width	0.259
upper arm	0.186
lower arm	0.146
hand	0.108
shoulder width	0.259
chest width	0.174
hip width/leg separation	0.191
upper leg (thigh)	0.245
lower leg (calf)	0.246
ankle to bottom of foot	0.039
foot breadth	0.055
foot length	0.152

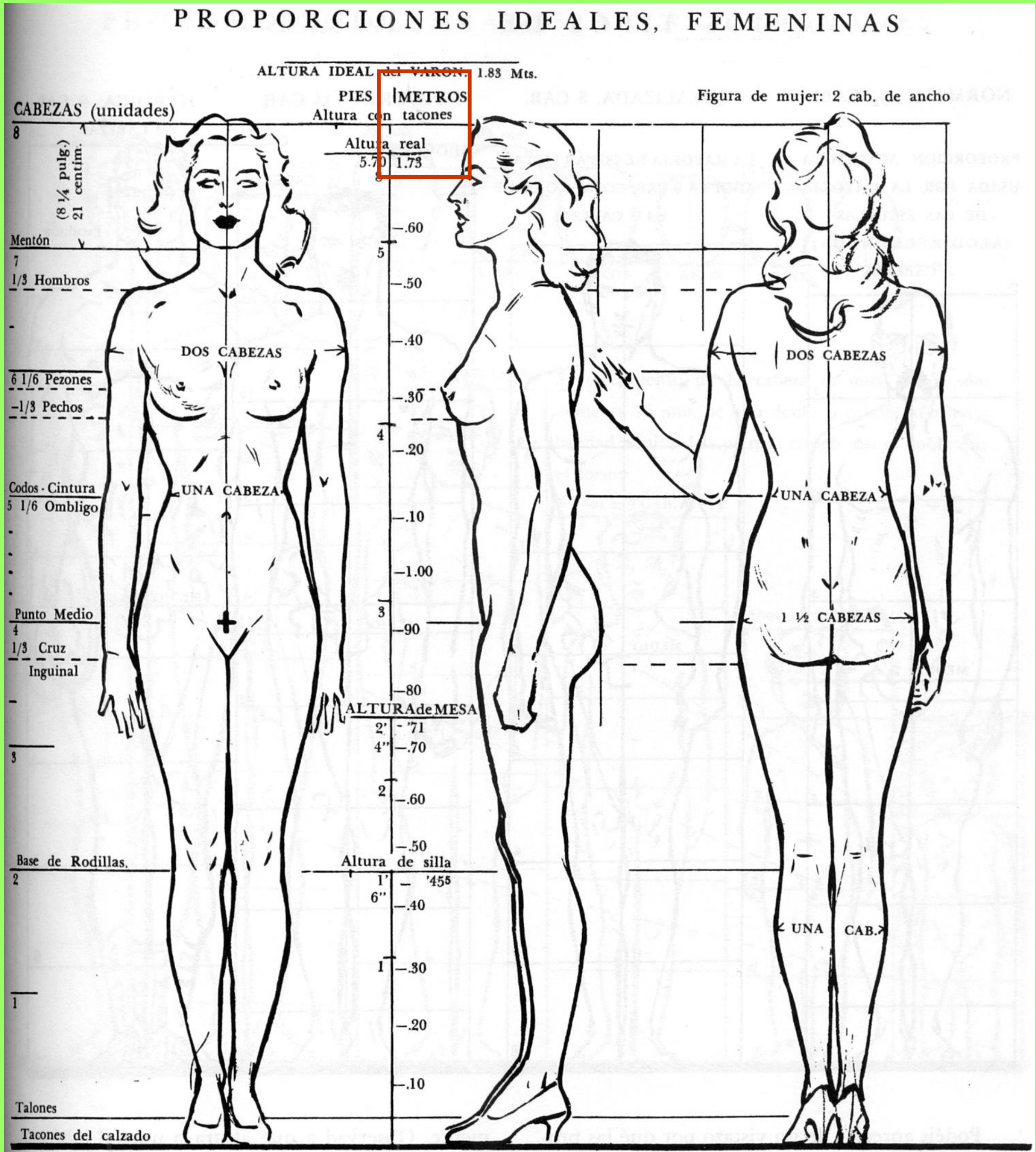
[a] Unless otherwise specified.

EL HOMBRE ESTANDARD DE LOOMIS I

Andrew Loomis, "El dibujo de la figura en todo su valor", Lancelot, 2008.

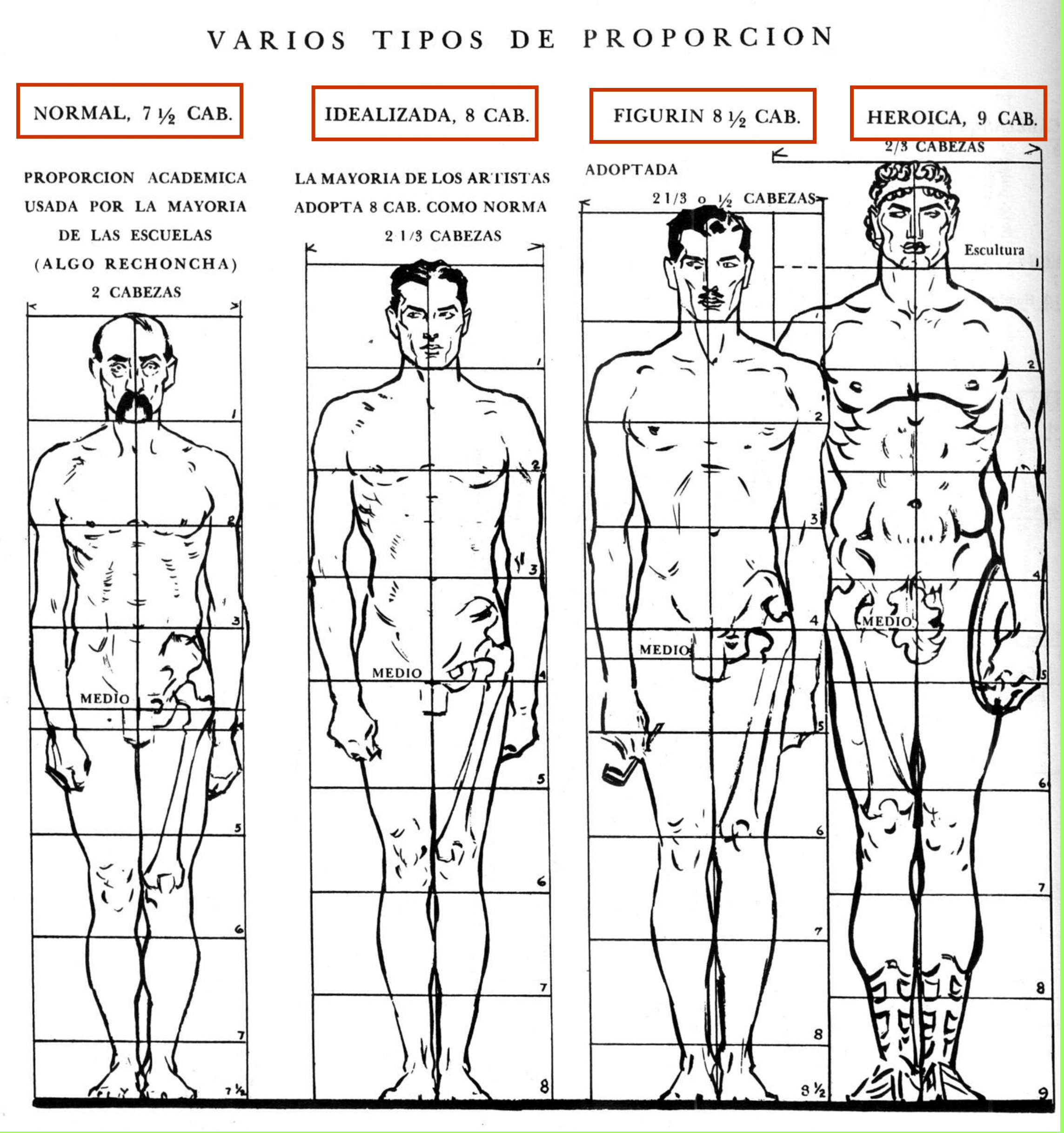


LA MUJER ESTANDARD DE LOOMIS



Andrew Loomis, "El dibujo de la figura en todo su valor ", Lancelot, 2008.

EL HOMBRE ESTANDARD DE LOOMIS II



Andrew Loomis, "El dibujo de la figura en todo su valor", Lancelot, 2008.

VOLUMETRIA DE SEGMENTOS POR INMERSION EN AGUA

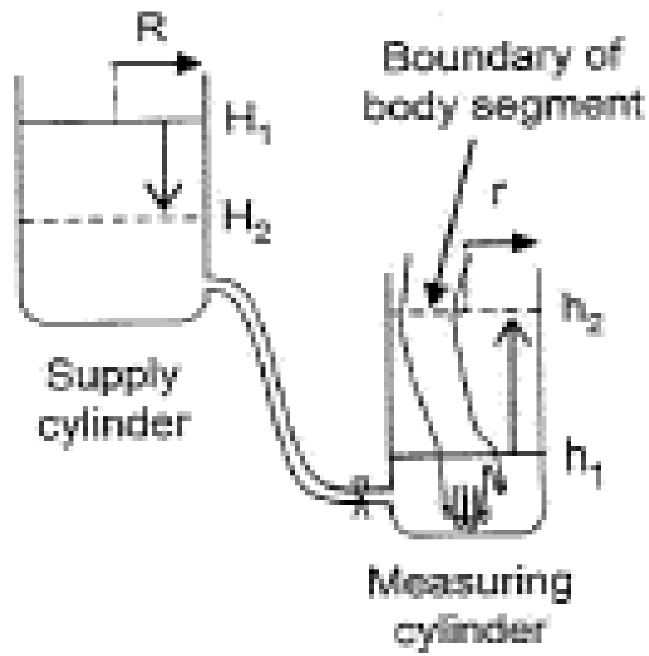


Fig. 1.18. Immersion technique for measuring the volume of various body segments, with the solid lines denoting the initial water level and the dashed lines the final water level. (Based on [48].) For Problem 1.37

MASAS Y DENSIDADES DE LOS SEGMENTOS

Table 1.7. Masses and mass densities of body segments. (Using data from [63])

segment	segment mass/ total body mass m_b	mass density (g/cm^3)
hand	0.006	1.16
forearm	0.016	1.13
upper arm	0.028	1.07
forearm and hand	0.022	1.14
total arm	0.050	1.11
foot	0.0145	1.10
lower leg (calf)	0.0465	1.09
upper leg (thigh)	0.100	1.05
foot and lower leg	0.061	1.09
total leg	0.161	1.06
head and neck	0.081	1.11
trunk	0.497	1.03

Densidad promedio: 1,0775 $g/cm^3 \approx$ 1,08 g/cm^3

[63] D.A. Winter: *Biomechanics and Motor Control of Human Movement.* 3rd edition, Wiley, New York, 2005.

PESO DE LOS SEGMENTOS

Table 1.16. An alternative set of relations of weights of body segments (all in lb). (Using data from [48], which used unpublished data by [40])

segment	segment weight
head	$0.028W_b + 6.354$
trunk	$0.552W_b - 6.417$
upper arms	$0.059W_b + 0.862$
forearms	$0.026W_b + 0.85$
hands	$0.009W_b + 0.53$
upper legs	$0.239W_b - 4.844$
lower legs	$0.067W_b + 2.846$
feet	$0.016W_b + 1.826$

CENTRO DE MASA DEL CUERPO Y DE LOS SEGMENTOS

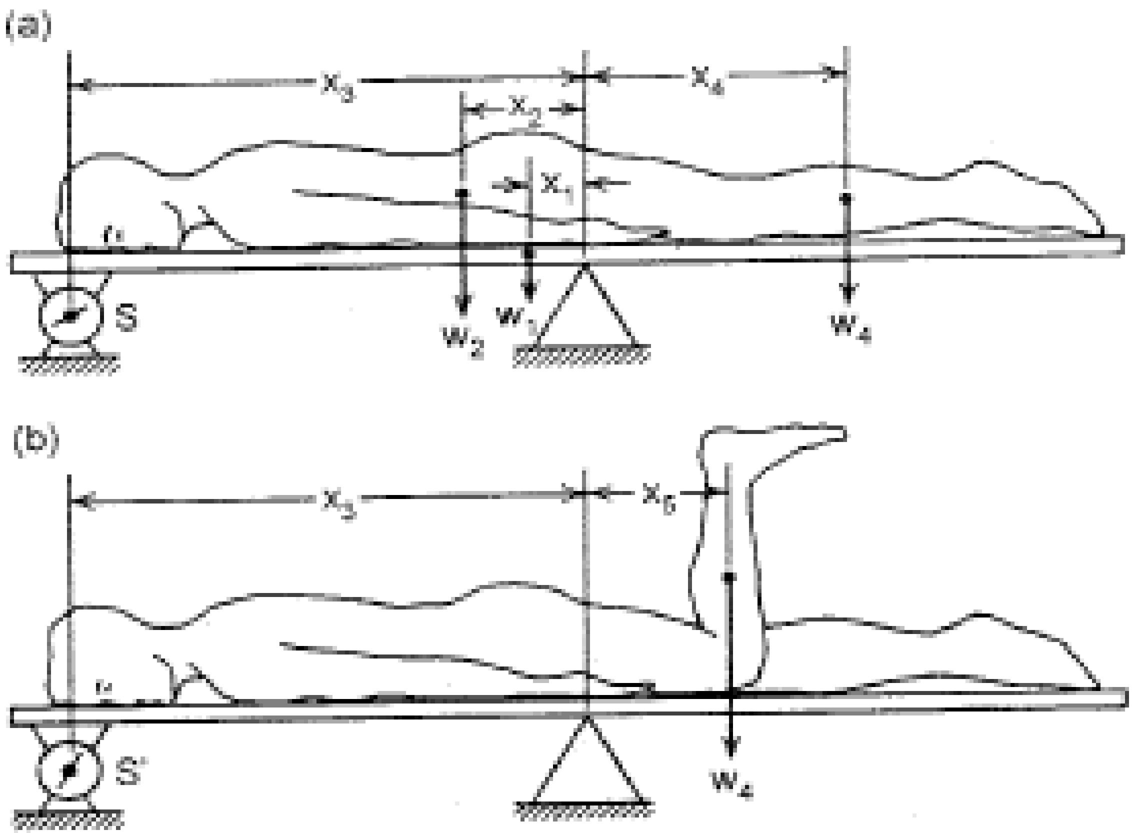


Fig. 1.20. In vivo estimation of (a) body center of mass and (b) mass of a distal segment, for Problems 1.42 and 1.43. (From [63]. Reprinted with permission of John Wiley & Sons)

[63] D.A. Winter: *Biomechanics and Motor Control of Human Movement.* 3rd edition, Wiley, New York, 2005.

LOCALIZACION DEL CENTRO DE MASA DE SEGMENTOS

Table 1.8. Distance of the center of mass from either segment end, normalized by the segment length. (Using data from [63])

segment	center of mass from	
	proximal	distal
hand	0.506	0.494
forearm	0.430	0.570
upper arm	0.436	0.564
forearm and hand	0.682	0.318
total arm	0.530	0.470
foot	0.50	0.50
lower leg (calf)	0.433	0.567
upper leg (thigh)	0.433	0.567
foot and lower leg	0.606	0.394
total leg	0.447	0.553
head and neck	1.00	–
trunk	0.50	0.50

[63] D.A. Winter: *Biomechanics and Motor Control of Human Movement.* 3rd edition, Wiley, New York, 2005.

MOMENTO DE INERCIA Y TEOREMA DE STEINER

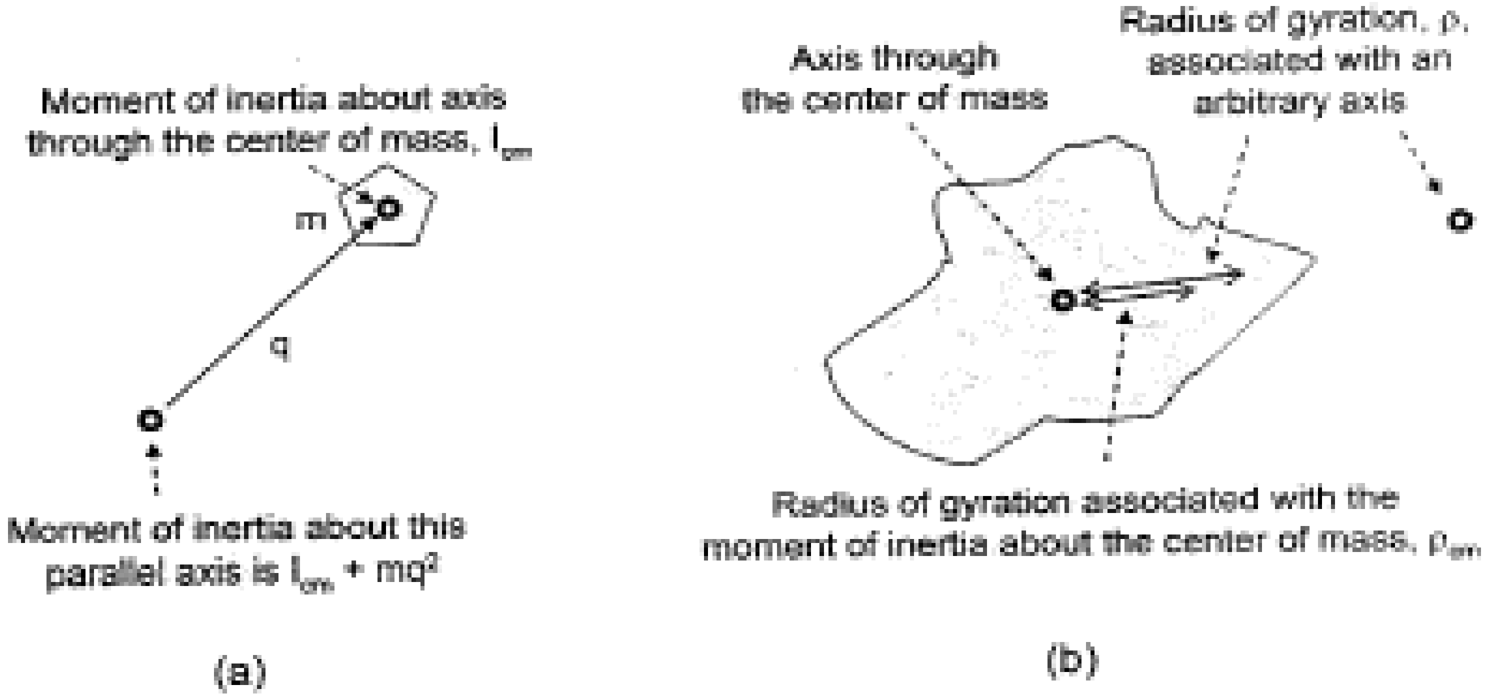


Fig. 3.23. (a) The parallel axis theorem is illustrated for an object of mass m for an axis about the center of mass normal to the page and about an arbitrary parallel axis, and (b) the radius of gyration is schematically illustrated for moments of inertia about the center of mass and an arbitrary axis

RADIO DE GIRO DE SEGMENTOS

Table 1.9. Radius of gyration of a segment, about the center of mass and either end, normalized by the segment length. (Using data from [63])

segment	radius of gyration about		
	C of M	proximal	distal
hand	0.297	0.587	0.577
forearm	0.303	0.526	0.647
upper arm	0.322	0.542	0.645
forearm and hand	0.468	0.827	0.565
total arm	0.368	0.645	0.596
foot	0.475	0.690	0.690
lower leg (calf) pantorrilla	0.302	0.528	0.643
upper leg (thigh) muslo	0.323	0.540	0.653
foot and lower leg	0.416	0.735	0.572
total leg	0.326	0.560	0.650
head and neck	0.495	0.116	–

POSTURAS Y MOVIMIENTOS

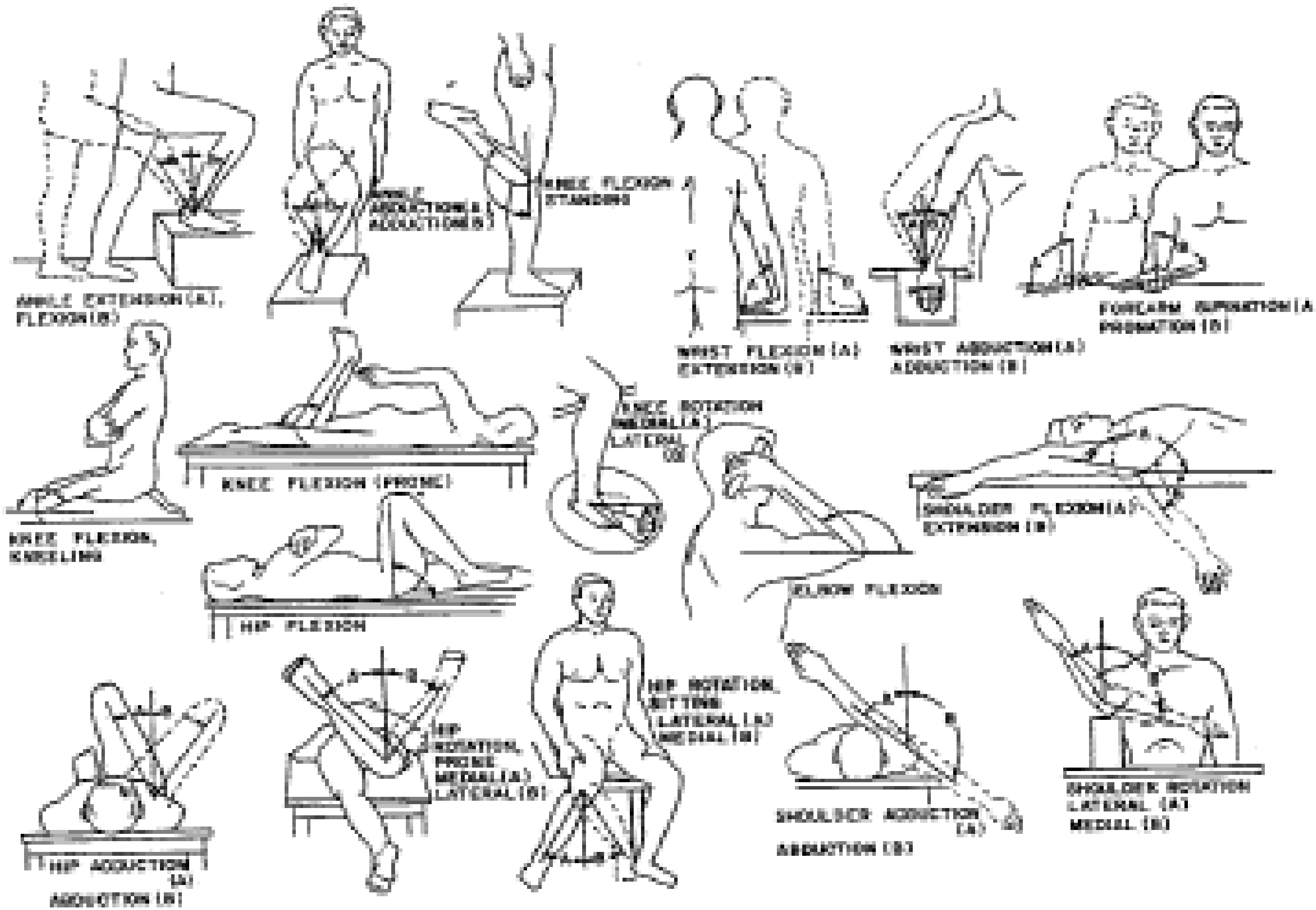


Fig. 1.16. Postures used for Table 1.10, for range of opposing motions. (From [38]. Reprinted with permission of Wiley. Also see [33, 61])

MOVILIDAD DE ARTICULACIONES

Table 1.10. Range of joint mobility for opposing movements, with mean and standard deviation (SD) in degrees. (Using data from [39], as from [33, 61])

1957 1978 1999

opposing movements	mean	SD
shoulder flexion/extension	188/61	12/14
shoulder abduction/adduction	134/48	17/9
shoulder medial/lateral rotation	97/34	22/13
elbow flexion	142	10
forearm supination/pronation	113/77	22/24
wrist flexion/extension	90/99	12/13
wrist abduction/adduction	27/47	9/7
hip flexion	113	13
hip abduction/adduction	53/31	12/12
hip medial/lateral rotation (prone)	39/34	10/10
hip medial/lateral rotation (sitting)	31/30	9/9
knee flexion (prone) – voluntary, arm assist	125,144	10,9
knee flexion – voluntary (standing), forced (kneeling)	113,159	13,9
knee medial/lateral rotation (sitting)	35/43	12/12
ankle flexion/extension	35/38	7/12
foot inversion/eversion	24/23	9/7

The subjects were college-age males. Also see Fig. 1.16.

DENSIMETRIA Y CONTENIDO DE GRASA CORPORAL I

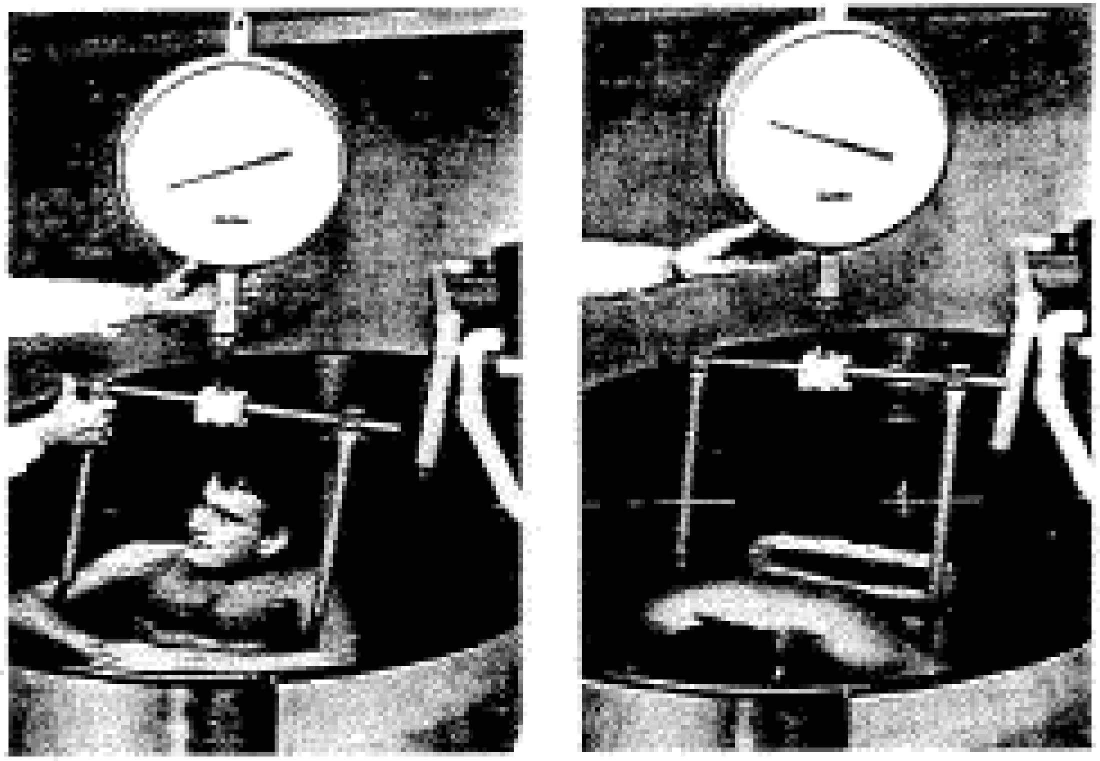


Fig. 1.19. Determining human body fat content and density by weighing a person in water. (Photo by Clifton Boutelle, News and Information Service, Bowling Green State University. Used with permission of Brad Phalin. Also see [41].) For Problem 1.40

DENSIMETRIA Y CONTENIDO DE GRASA CORPORAL II

Table 1.17. Comparison of the density and fat percentage for two men with the same height and mass, but different underwater masses. (Using data from [62].) For Problem 1.40

parameter	man A	man B
height, m (in)	1.88(74)	1.88(74)
mass, kg (lb)	93(205)	93(205)
underwater mass, kg	5.00	3.50
volume, L	88.0	89.5
$\text{volume}_{\text{corrected}}$ [a], L	86.5	88.0
body density[b], g/cm^3	1.075	1.057
relative fat, %	10.4	18.4
fat mass, kg (lb)	9.7(21.4)	17.1(37.7)
fat-free mass, kg (lb)	83.3(183.6)	75.9(167.3)

[a] The volume is corrected for the water density, intestinal gas volume, and residual lung volume.

[b] The body density is the mass-corrected volume. Relative fat (in %) = 100(4.95/(body density) − 4.50). Fórmula de Siri.

$$Grasa_{Siri}(\%) = 100\left(4,95/\rho_{Corporal}\right) - 4,50$$

$$Grasa_{Brozek}(\%) = 100\left(4,570/\rho_{Corporal}\right) - 4,142$$

EL HOMBRE ESTANDARD CILINDRICO

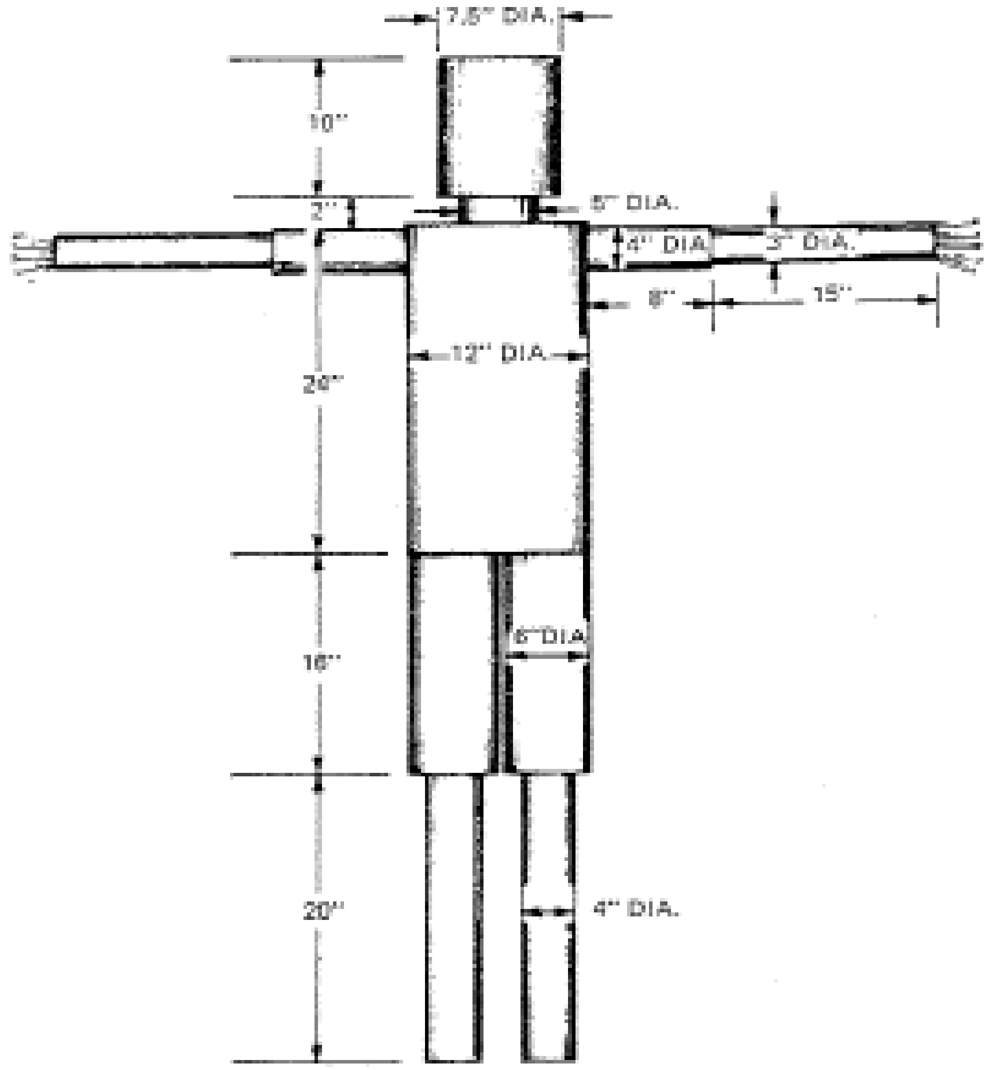


Fig. 1.17. Cylindrical model of a man used in studies of convective cooling. (From [34], adapted from [51])

Table 1.11. Mass and volume of the organs of the human body. (Using data from [42])

fluid, tissue, organ, or system	total mass (g)	total volume (cm^3)
adult male body	70,000	60,000
muscle	30,000	23,000
fat	10,500	12,000
skin	2,000	1,800
subcutaneous tissue	4,100	3,700
skeleton	10,000	6,875
gastrointestinal track	2,000	1,800
contents (chyme/feces)	~2,000	~2,000
blood vessels	1,800	1,700
contents (blood)	5,600	5,400
liver	1,650	1,470
brain	1,400	1,350
lungs (2)	825	775
contents (air)	~7.7	~6,000
heart	330	300
chamber volume	–	450
kidneys (2)	300	270
urinary bladder	150	140
contents (urine)	~500	~500
digestive fluids	~150	~150
pancreas	110	100
salivary glands (6)	50	48
synovial fluid	~50	~50
teeth (32)	42	14
eyes (2)	30	27
hair (average haircut)	21	16
gall bladder	7	7
contents (bile)	~50	~50
fingernails and toenails (20)	1.1	0.9

MASA Y VOLUMEN DE ORGANOS

Densidad promedio: 1,166 g/cm^3 ≈ 1,17 g/cm^3

[42] R.A. Freitas, Jr.: *Nanomedicine, Volumen I: Basic Capabilities.* Landes Bioscience, Austin, 1999.

CONTENIDO MOLECULAR CELULAR

Table 1.12. Estimated gross molecular contents of a typical 20-μm human cell. (Using data from [42])

molecule	mass (%)	molecular weight (amu, daltons)	number of molecules	number of molecular entities
water	65	18	1.74×10^{14}	1
other inorganic	1.5	55	1.31×10^{12}	20
lipid (fat)	12	700	8.4×10^{11}	50
other organic	0.4	250	7.7×10^{10}	~200
protein	20	50,000	1.9×10^{10}	~5,000
RNA	1.0	1×10^{6}	5×10^{7}	–
DNA	0.1	1×10^{11}	46	–

Número total de moléculas: 17.622.705.000.046

BIOFISICA

CAPITULO 1

Relaciones de Escala entre los Mamíferos y entre los Humanos.

Relaciones Isométricas y Alométricas.

Iso (griego) ≡ Igual

Alloios (griego) ≡ Diferente

DESARROLLO HUMANO Y REGLAS ALOMETRICAS I

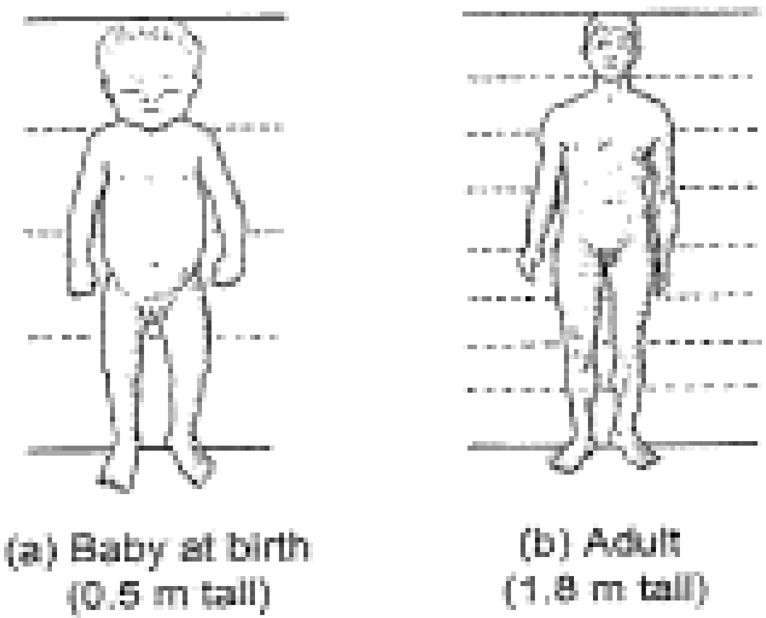


Fig. 1.21. Human development, showing the change in body shape from birth to adulthood, for Problem 1.54. (From [54])

DESARROLLO HUMANO Y REGLAS ALOMETRICAS II

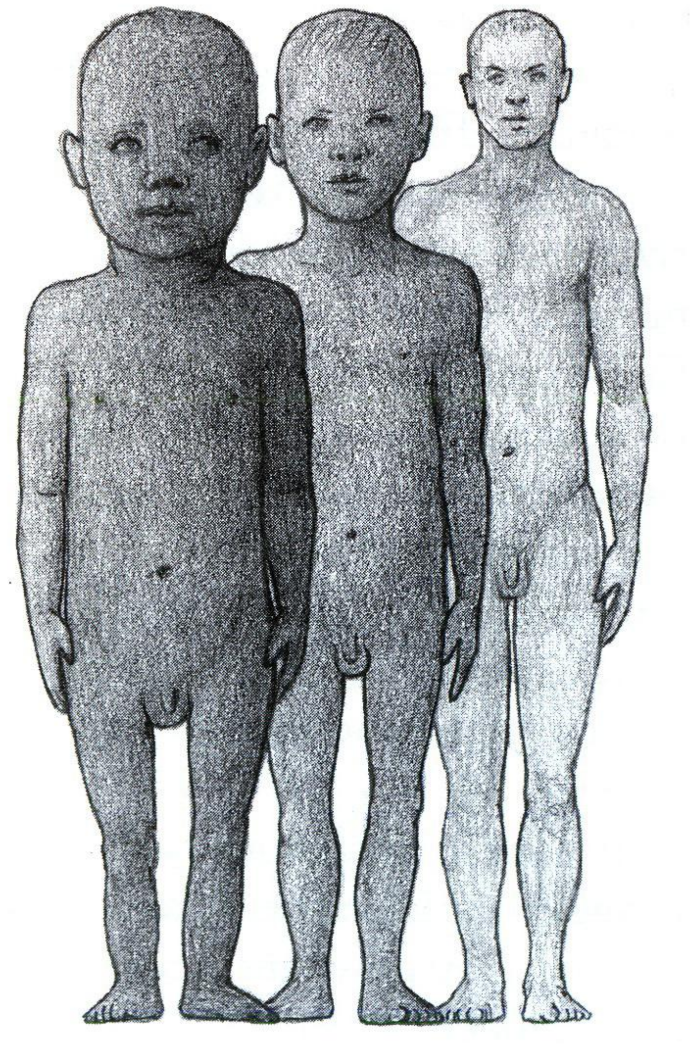
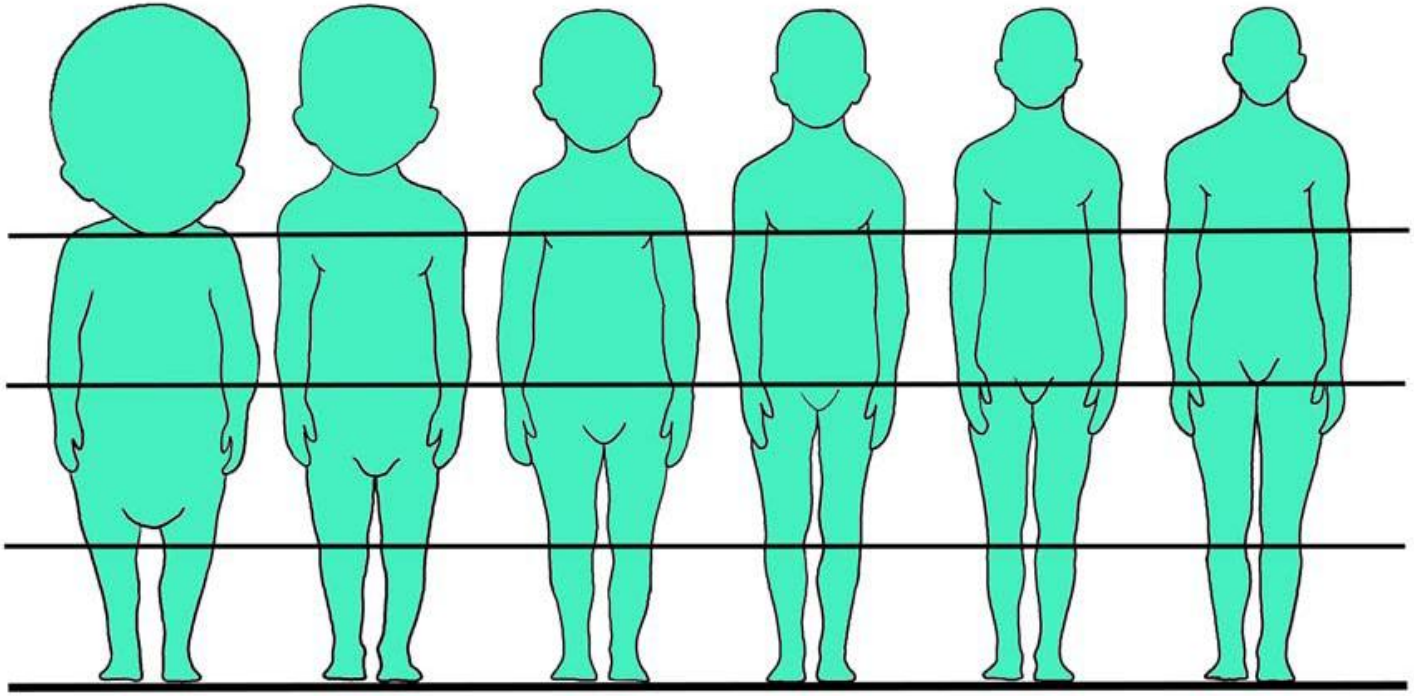
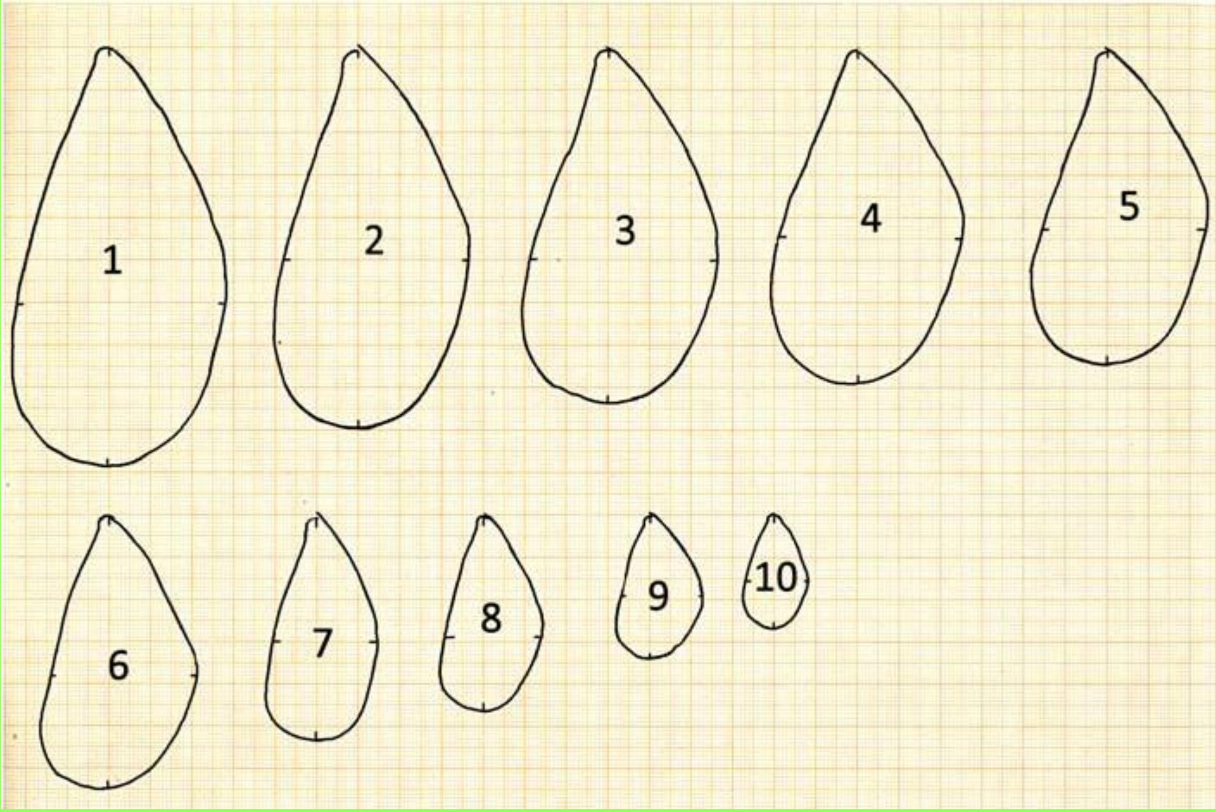


Figura 8.2. Cambio de proporciones entre las partes del cuerpo (alometría) durante el crecimiento. A la izquierda un niño recién nacido, en el centro un niño de 3 años, a la derecha un adulto.Todos al mismo tamaño.



edad	longitud total	Longitud cabeza	Longitud hombros
8 semanas	2.5 cm	1.1 cm	1.5 cm
12 semanas	8.1 cm	2.9 cm	5.4 cm
16 semanas	15.2 cm	4.6 cm	10.7 cm
nacimiento	50.0 cm	11.8 cm	38.1 cm
2 años	87.0 cm	17.6 cm	68.2 cm
5 años	108.0 cm	18.9 cm	87.7 cm
15 años	170.0 cm	25.1 cm	142.7 cm
adulto	177.0 cm	26.2 cm	146.4 cm

Tabla 1. Medidas corporales humanas en diferentes edades.


1
2
3
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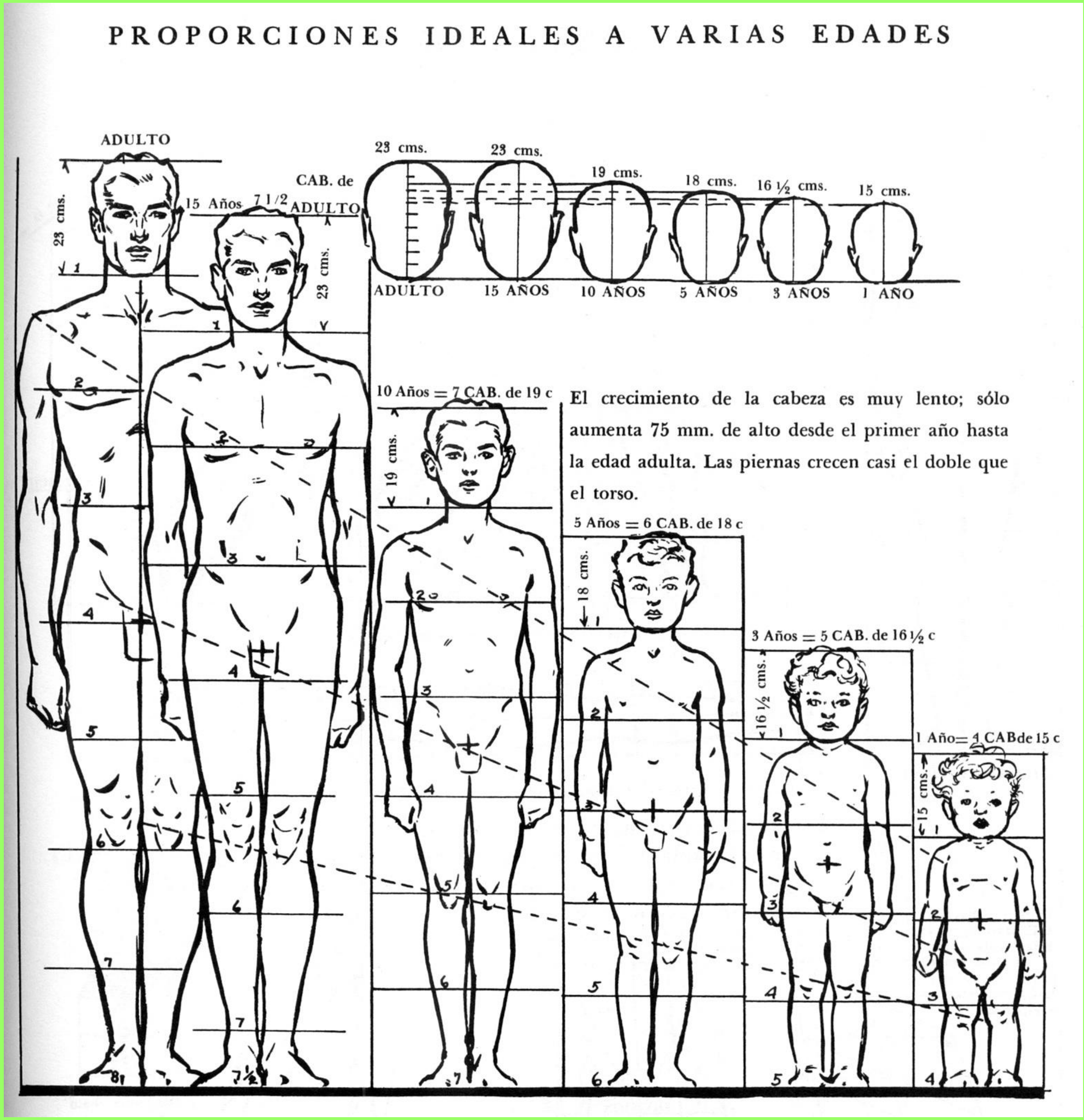
5
6
7
8
9
10

DESARROLLO HUMANO Y REGLAS ALOMETRICAS III



PARAMETROS ALOMETRICOS PARA LOS MAMIFEROS

Table 1.13. Allometric parameters (1.1) for mammals. (Using data from [31, 55])

Humanos: $m_b = 70\ kg$

parameter	a	α
basal metabolic rate (BMR), in W	4.1	0.75
body surface area, in m^2	0.11	0.65
brain mass in man, in kg	0.085	0.66
brain mass in nonprimates, in kg	0.01	0.7
breathing rate, in Hz	0.892	−0.26
energy cost of running, in J/m-kg	7	−0.33
energy cost of swimming, in J/m-kg	0.6	−0.33
effective lung volume, in m^3	5.67×10^{-5}	1.03
heart beat rate, in Hz	4.02	−0.25
heart mass, in kg	5.8×10^{-3}	0.97
lifetime, in y	11.89	0.20
muscle mass, in kg	0.45	1.0
skeletal mass (terrestrial), in kg	0.068	1.08
speed of flying, in m/s	15	0.167
speed of walking, in m/s	0.5	0.167

81,36 W

99,22 W

1,74 m^2

1,85 m^2

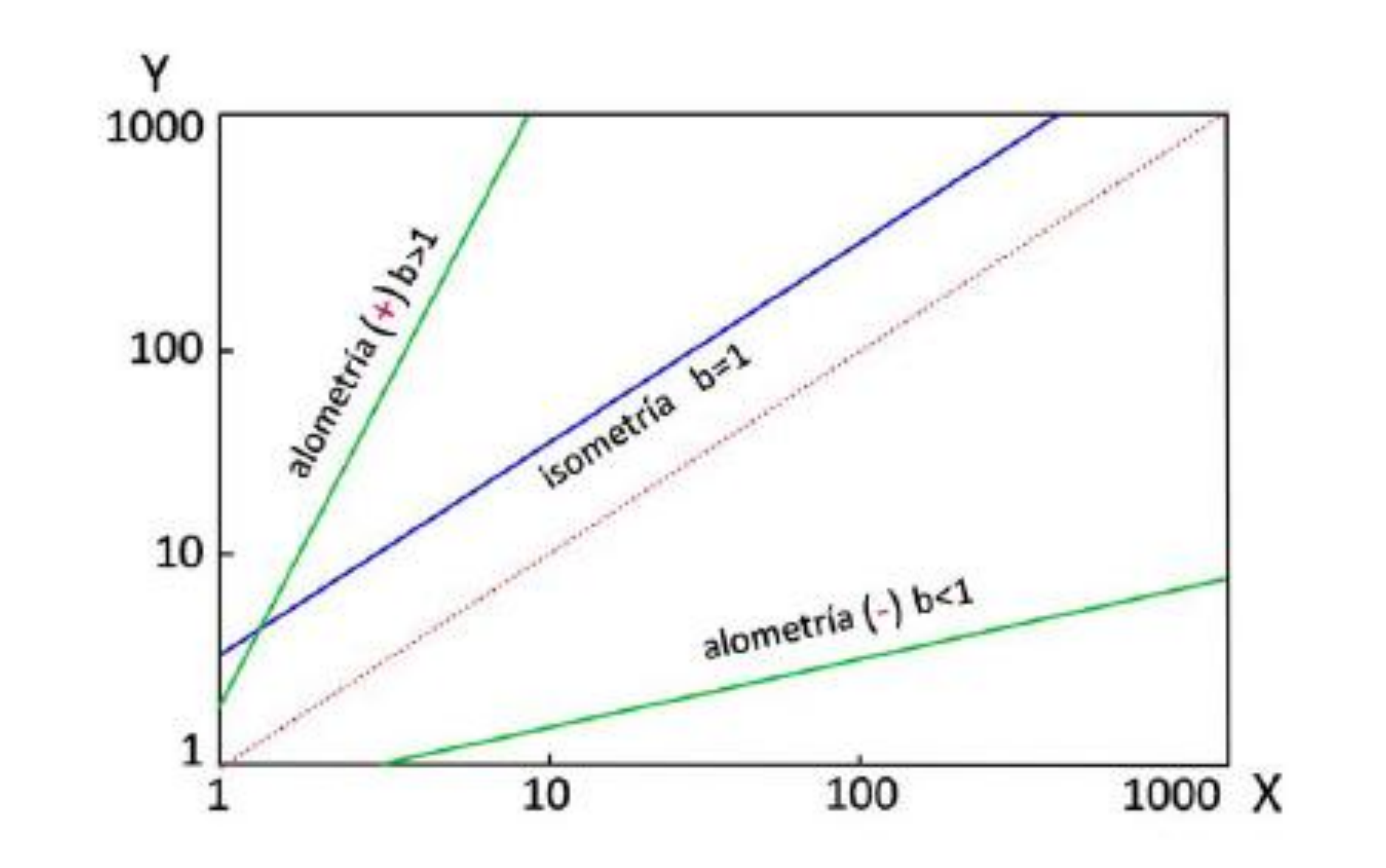
Hombre Standard

¡27,81 años!

31,50 kg

$$f\text{ (en las unidades adecuadas)} = a\, m_b^{\alpha}.$$

La relación es alométrica si $\alpha \neq 1$.


Y
1000
100
10
1
1
10
100
1000
X
alometría (+) b>1
isometría b=1
alometría (-) b<1

METABOLISMO PARA MAMIFEROS. LEY DE KLEIBER

$$BMR = c m_b^{3/4} \text{ , siendo } c \approx 90 \ kcal/kg^{3/4} día$$

Table 6.18. BMR determined for several mammals. (See, for example [324])

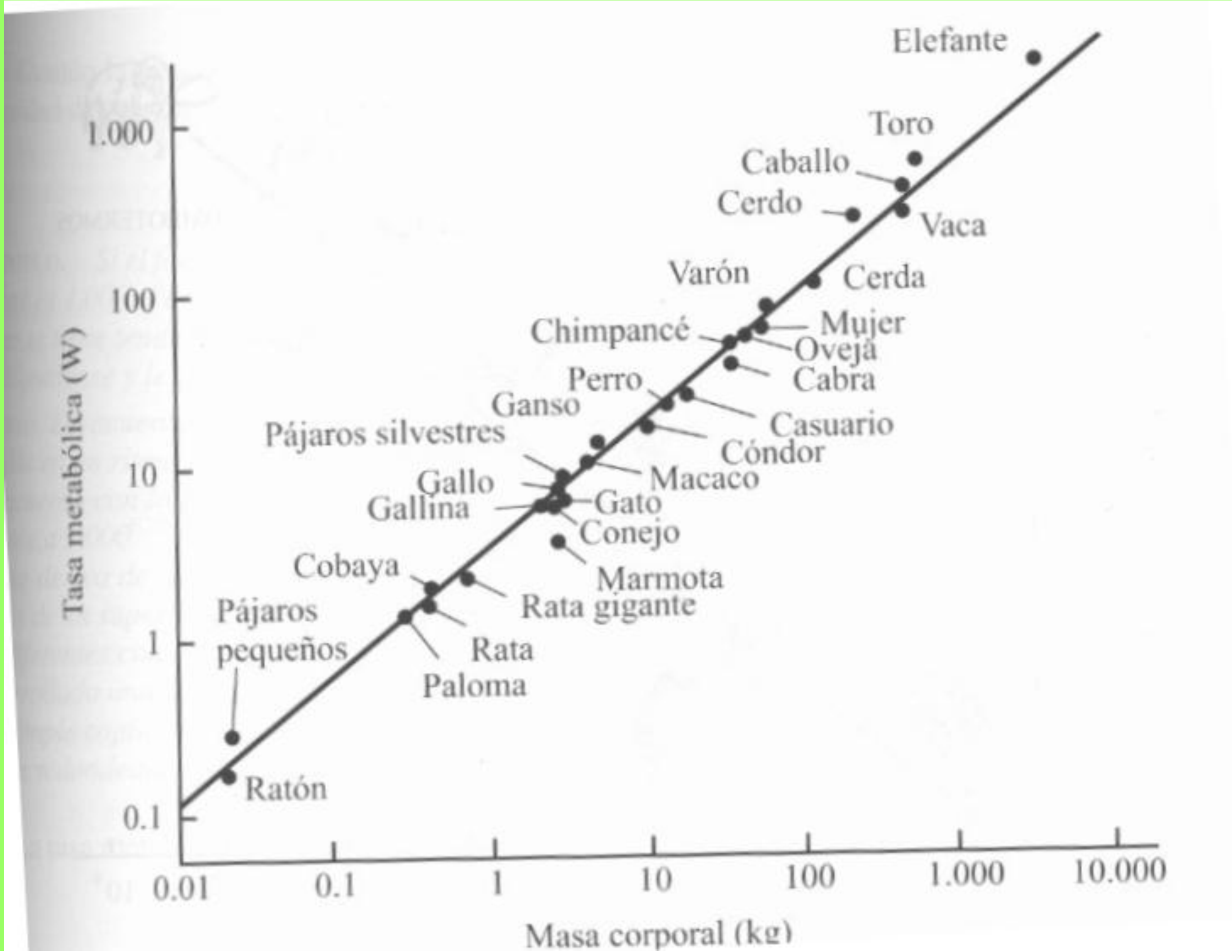
1984

species	mass	BMR (kcal/day)
mouse	20 g	3
reference woman (25 years)	55 kg	1,260
reference man (25 years)	65 kg	1,500
elephant	5,000 kg	70,000

Para el "hombre estandar" de m_b = 70 kg, resulta el BMR = 2178 kcal/día, mientras que habíamos visto que resultaba aceptado el valor de 1680 kcal/día.

METABOLISMO PARA MAMIFEROS. LEY DE KLEIBER

BMR = $cm_b^{3/4}$, siendo $c \approx 90\ kcal/kg^{3/4}día$



LEY DE KLEIBER I

- Muchas de las relaciones alométricas propuestas son puramente empíricas y no generalizables, mientras que otras aparecen como deducibles, racionalizadas a partir de argumentos complicados.
- Un ejemplo, es la comparación de las patas de los grandes mamíferos, como el elefante –muy anchas en proporción a sus dimensiones lineales L (y a sus masas m_b)– y las de los pequeños mamíferos, como el ratón.
- La argumentación se basa en dos suposiciones:

1) La densidad media δ de los mamíferos es constante.
2) La carga máxima a la compresión de los huesos largos de los mamíferos es constante.

LEY DE KLEIBER II

- El elefante tiene unas patas de huesos muy anchos, w_h, en proporción a sus dimensiones lineales generalizadas L y a su masa corporal m_b, comparados con el ratón. Lo mismo ocurre con la longitud de los huesos largos L_h.
- Las características de los huesos largos dependen de la masa que deben soportar, y $m_b \alpha L^3$, ya que la densidad media δ de los mamíferos es constante.
- Asimismo, como la carga máxima a la compresión de los huesos largos de los mamíferos es constante, soportan igual carga por unidad de área de la sección del hueso, la que es proporcional a w_h^2. Luego, $w_h^2 \alpha m_b \alpha L^3$, con lo que $w_h \alpha L^{3/2}$.

LEY DE KLEIBER III

- Y como $L_h \alpha L$, se puede escribir:

$$w_h / L_h^3 \alpha L^{3/2} / L_h^3 \approx L^{1/2},$$

con lo que:

$$w_h / L_h^3 \alpha L^{1/2},$$

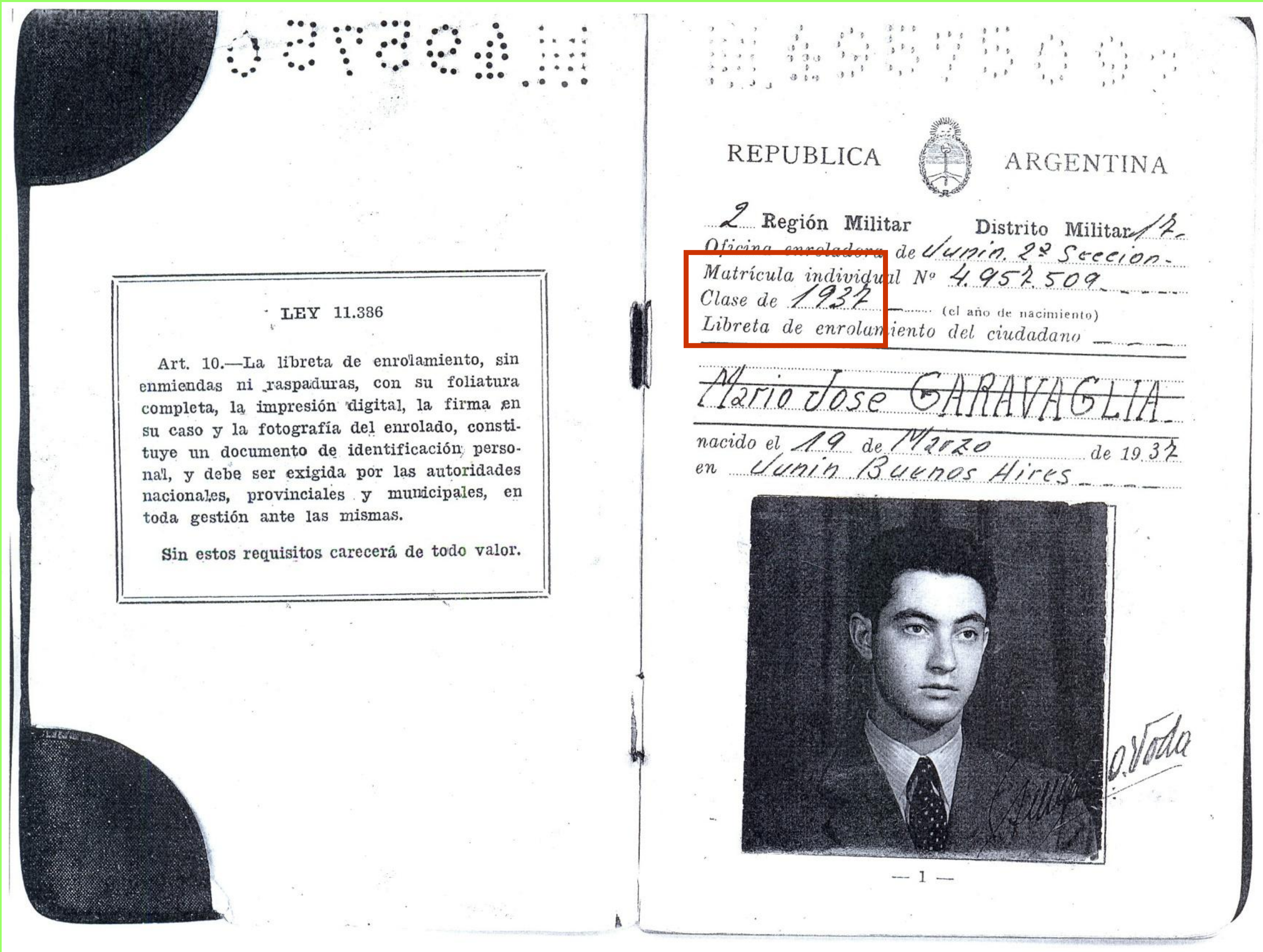
y como la densidad media $\delta \approx m_b / L^3$, resulta: $L^3 \alpha m_b$, o bien: $L \alpha m_b^{1/3}$, con lo que:

$$w_h / L_h^3 \alpha L^{1/2} \alpha m_b^{1/6}.$$

- Luego, la relación de w_h / L_h^3 del elefante al ratón será igual a la relación de $m_b^{1/6}$ del elefante al ratón:

$(m_b^{1/6})_{elefante} /(m_b^{1/6})_{ratón} = (250.000)^{1/6} \approx 7,94.$

ALTURA vs EDAD I



LEY 11.386

Art. 10.—La libreta de enrolamiento, sin enmiendas ni raspaduras, con su foliatura completa, la impresión digital, la firma en su caso y la fotografía del enrolado, constituye un documento de identificación personal, y debe ser exigida por las autoridades nacionales, provinciales y municipales, en toda gestión ante las mismas.

Sin estos requisitos carecerá de todo valor.

REPUBLICA ARGENTINA

2 Región Militar Distrito Militar 17

Oficina enroladora de Junín 2ª Sección

Matrícula individual Nº 4.957.509

Clase de 1937 (el año de nacimiento)

Libreta de enrolamiento del ciudadano

Mario José GARAVAGLIA

nacido el 19 de Marzo de 1937

en Junín Buenos Aires

— 1 —

ALTURA vs EDAD II

Filiación (1)

Color de la piel: Blanca - trigueña - negra.
Ojos: azules-verdosos-pardos-negros; chicos-medianos-grandes.
Nariz: recta-aguileña-deprimida; chica-mediana-grande.
Talla: 1 metro y 78 cm.
Señas particulares visibles: ninguna
y con actual domicilio en:
Provincia o territorio Buenos Aires
Partido o departamento Junín
Cuartel, pedanía, sección o distrito 4
Ciudad, pueblo localidad paraje o isla Junín
Calle (2) Mayor Arrieta Nº 1363

Firma del enrolado

Lugar y fecha de enrolamiento
Junín Marzo
29 de 1955

Sello

Jefe de la Oficina Enroladora

Impresión digital del dedo pulgar de la mano derecha (3)

(1) Deben borrarse con una línea las designaciones que no correspondan al enrolado.
(2) Donde no la hubiere, nombre de la finca, estancia o establecimiento.
(3) O de otro dedo, a falta de éste, indicando cuál es.

— 2 —

Servicio de conscripción

En fecha 11 de Setiembre de 1957
Por haberle correspondido en el sorteo de la clase de 1937 el núm. 431 debe hacer el servicio en

Sello

JULIO CESAR BRIZUELA SANCHEZ
Jefe del Distrito Militar
JEFE INTERINO DISTRITO MILITAR 17

D	M	A	ALTAS Y BAJAS
11	III	58	Alta procedente de D. M. 17 Incorporado a Co. de Vig. (subunidad) del Dest. Vig. Cu. R. 7 (unidad)
2	II	59	Pasó a Baja por (1) Licenciamiento parcial de la clase (Nota Letra "Conf." Nº 1014. C.M.G.E.)

Período de instrucción Ejercicios Finales
Ascensos 15-IX-58 - a Sol. Cpto. Dgto. (O. D. R. Nº 30/58)
Aptitud y especialidad que posee al dejar el servicio JEFE GRUPO TIRADORES

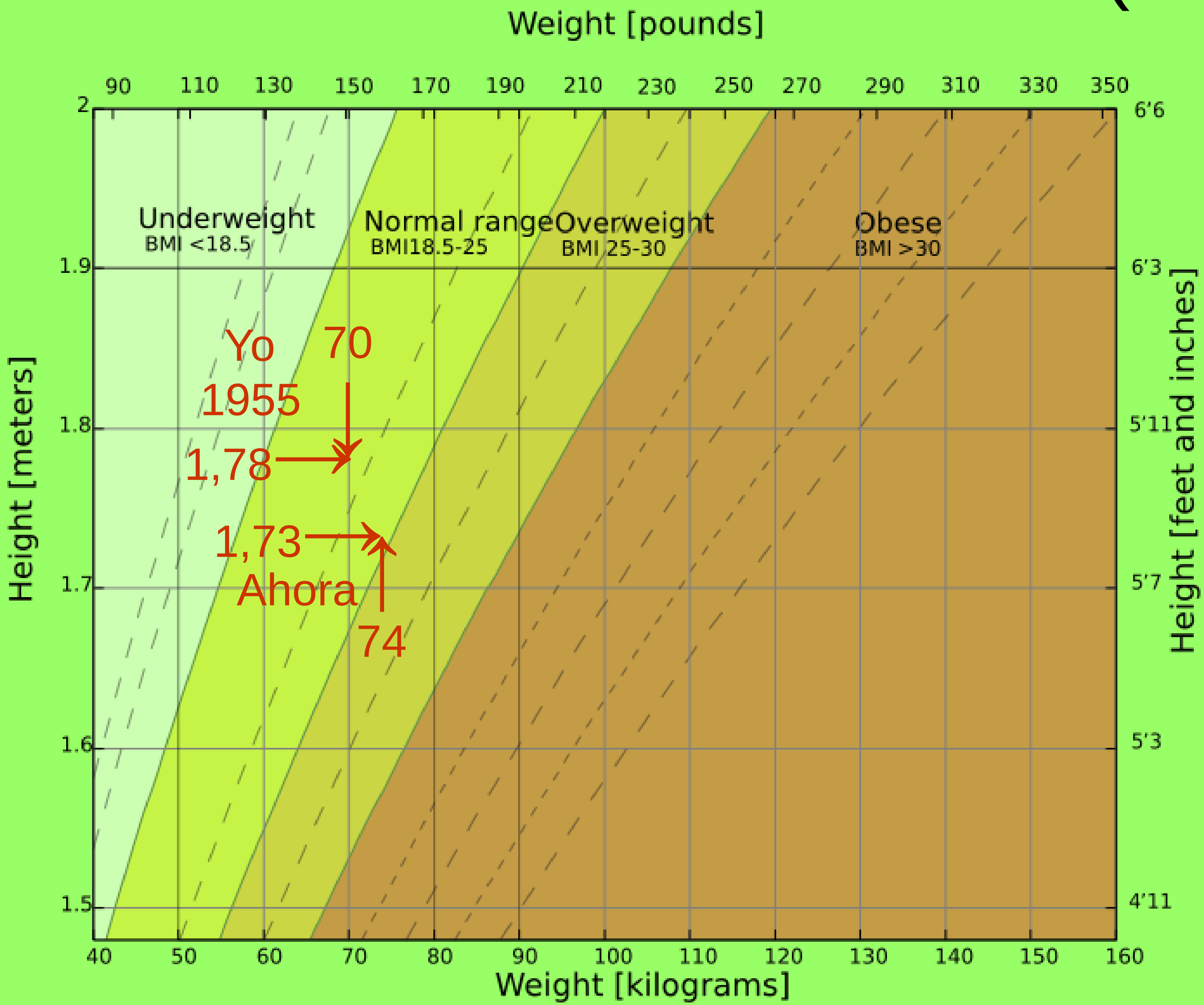
Sello

MARIO O. HACHQUETALEPO
CAPITAN
JEFE DEST. VIG. CUARTEL B. 7
Jefe de la Subunidad

(1) Exclusivamente para los incorporados, debiendo indicarse la disposición legal o prescripción reglamentaria (artículo, inciso, etcétera) y letra, número y fecha del expediente pertinentes en su caso.

— 3 —

INDICE DE QUÉTELET ($Q = m_b/H^2$) o INDICE DE MASA CORPORAL (BMI)



LEY DE HARRIS-BENEDICT
(O LEY DE KLEIBER PARA HUMANOS)

$$BMR_{Mujer} = 65,8 m_b^{3/4}\left[1 + 0,004\left(30 - Y\right) + 0,010\left(S - 43,4\right)\right]$$

$$BMR_{Hombre} = 71,2 m_b^{3/4}\left[1 + 0,004\left(30 - Y\right) + 0,010\left(S - 43,4\right)\right]$$

Y , es la edad expresada en años.

$S = H\left(cm\right) \Big/ \left[m_b\left(kg\right)\right]^{1/3}$, es la estatura específica.

$\rho\left(kg/m^3\right) = 0,69 + 0,9S$, es la densidad.

$Grasa_{Hombres}\left(\%Peso\right) = 1,28Q - 10,1$, es la grasa corporal.

$Grasa_{mujeres}(\%Peso) = 1.48Q - 7.0$, es la grasa corporal.

METABOLISMO, GENERO Y EDAD SEGUN LA LEY DE HARRIS-BENEDICT

Table 6.19. BMR (kcal/day) for different age groups. (Using data from [298], using [335])

age group (years)	BMR (males)	BMR (females)
Under 3	$59.5m_b - 30$	$58.3m_b - 31$
3–10	$22.7m_b + 504$	$20.3m_b + 486$
10–18	$17.7m_b + 658$	$13.4m_b + 693$
18–30	$15.1m_b + 692$	$14.8m_b + 487$
30–60	$11.5m_b + 873$	$8.1m_b + 846$
Over 60	$11.7m_b + 588$	$9.1m_b + 658$

m_b is the body mass in kg.

1674 kcal/día

1301 kcal/día

Tabla 6.18: 1500 kcal/día

1260 kcal/día

METABOLISMO, GENERO, EDAD E INDICE DE QUÉTELET

Table 6.20. BMR (kcal/day) for adult men and women of different ages, assuming Quételet's index (or BMI) Q is 22 for men and 21 for women and the relations in Table 6.19. (Using data from [298], from [305])

height (m) (also ft, in)	mass (kg) (also lb)	age (yr)		
		18–30	30–60	over 60
men				
1.5 (4′11″)	49.5 (109)	1,440	1,450	1,150
1.6 (5′3″)	56.5 (124)	1,540	1,530	1,250
1.7 (5′7″)	63.5 (140)	1,650	1,620	1,350
1.8 (5′11″)	71.5 (157)	1,770	1,710	1,450
1.9 (6′3″)	79.5 (175)	1,900	1,800	1,560
2.0 (6′7″)	88.0 (194)	2,030	1,900	1,670
women				
1.4 (4′7″)	41.0 (90)	1,100	1,190	1,030
1.5 (4′11″)	47.0 (104)	1,190	1,240	1,090
1.6 (5′3″)	54.0 (119)	1,290	1,300	1,160
1.7 (5′7″)	61.0 (134)	1,390	1,360	1,230
1.8 (5′11″)	68.0 (150)	1,500	1,420	1,310

PARAMETROS ADIMENSIONALES INDEPENDIENTES DEL TAMAÑO DE LOS MAMIFEROS

Table 1.14. Size-independent dimensionless groups in mammals. (Using data from [46])

parameter	a	α
breathing flow rate/blood flow rate[a]	2.0	0.00
mass of blood/mass of heart	8.3	0.01
time for 50% of growth/lifespan in captivity	0.03	0.05
gestation period/lifespan in captivity	0.015	0.05
breathing cycle/lifespan in captivity	3×10^{-9}	0.06
cardiac cycle/lifespan in captivity	6.8×10^{-10}	0.05
half-life of drug[b]/lifespan in captivity	0.95×10^{-5}	0.01

The value of a in (1.1) is that for a 1 kg mammal. Also see Chaps. 8 and 9.
[a] (tidal volume/breath time)/(heart stroke volume/pulse time).
[b] Methotrexate.

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Table 1.15. Exponent n for perceived strength (P) of a stimulus (S) above a threshold S_0, with $P = K(S - S_0)^n$ in Steven's Law. (Using data from [57, 58])

psychoperception	n	stimulus
brightness	0.33, 0.5	5° target, point source – dark adapted eye
loudness	0.54, 0.60	monoaural, binaural
smell	0.55, 0.60	coffee odor, heptane
vibration	0.6, 0.95	250 Hz, 60 Hz – on finger
taste	0.8, 1.3, 1.3	saccharine, sucrose, salt
temperature	1.0, 1.6	cold, warm – on arm
pressure on palm	1.1	static force on skin
heaviness	1.45	lifted weights
electric shock	3.5	60 Hz through fingers