FORMULA COLLECTION

FOR BIOPHYSICS AND BIOSTATISTICS

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PRACTICES

I. SEMESTER

MICROSCOPY I

$$D = \frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \frac{1}{o} + \frac{1}{i}$$

$$D = \frac{1}{f_1} + \frac{1}{f_2} = D_1 + D_2$$

$$M = \frac{I}{O} = \frac{i}{o}$$

$$M_{total} = M_{objective} \cdot M_{eyepiece}$$

MICROSCOPY II

$$\Delta s = d \sin \alpha_{\mathrm{k}} = \mathrm{k}\lambda$$

$$\delta = 0{,}61 \frac{\lambda}{n \sin \omega}$$

$$NA = n \cdot \sin \omega$$

$$f = \frac{1}{\delta}$$

$$M_{\mathrm{angle}} = -\frac{da}{f_{eyepiece} f_{objective}}$$

$$M_{k=\infty} = -\frac{a}{f}$$

$$k = d + f_{obj}$$

$$K = \frac{(J_{bright} - J_{dark})}{(J_{bright} + J_{dark})}$$

$$A_{res} = \sqrt{A_1^{\,2} + A_2^{\,2} + 2 A_1 A_2 \cos \Delta\varphi}$$

REFRACTOMETRY

$$c = f\lambda$$

$$n = \frac{c_{\mathrm{vacuum}}}{c_{\mathrm{medium}}}$$

$$n_{21} = \frac{n_2}{n_1}$$

$$\frac{\sin \alpha}{\sin \beta} = \frac{c_1}{c_2} = \frac{n_2}{n_1} = n_{21}$$

$$\frac{1}{\sin \beta_{\mathrm{c}}} = n_{21}$$

$$n = n_0 + kc$$

MEASUREMENT TECHNIQUES

$$H = \left| X_{meaured} - X_{true} \right|$$

$$h = \frac{\left| X_{\mathrm{measured}} - X_{\mathrm{true}} \right|}{X_{\mathrm{true}}} \cdot 100\%$$

$$U = RI$$

$$R_{series,res} = R_1 + R_2$$

$$\frac{1}{R_{parallel,res}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$U_1 = U_0 \cdot \frac{R_1}{(R_1 + R_2)}$$

$$U_{\mathrm{pp}} = 2U_{\max} = 2\sqrt{2}U_{\mathrm{eff}}$$

RESONANCE

$$F = -k\,x$$

$$F_{grav} = mg$$

$$x = A\sin(\varphi_0 + \omega t)$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$\omega = 2\pi f$$

$$f = \frac{1}{T}$$

$$x = A_0 e^{-\delta t}\sin(\omega t)$$

$$A = A_0 e^{-\delta t}$$

$$k_{parallel,res} = k_1 + k_2$$

$$\frac{1}{k_{series,res}} = \frac{1}{k_1} + \frac{1}{k_2}$$

LIGHT EMISSION

$$\varepsilon = hf = h\frac{c}{\lambda}$$

$$\lambda_{\max} T = \mathrm{b}$$

$$hf = E_j - E_i$$

LIGHT ABSORPTION

$$hf = E_j - E_i$$

$$\varepsilon = hf = h\frac{c}{\lambda}$$

$$T = \frac{J}{J_0}(100\%)$$

$$A = \lg\left(\frac{J_0}{J}\right) = \varepsilon(\lambda)cx$$

OPTICS OF THE EYE

$$D = \frac{n}{o} + \frac{n'}{i}$$

$$\Delta D = D_{\mathrm{p}} - D_{\mathrm{r}} = \frac{1}{o_{\mathrm{p}}} - \frac{1}{o_{\mathrm{r}}}$$

$$D_t = \sum_i D_i$$

$$\text{visus} = \frac{1(')}{\alpha(')}100\%$$

$$\alpha(') \approx \frac{a}{x}(\text{rad})\frac{360(^\circ)}{2\pi(\text{rad})}60\left(\frac{'}{^\circ}\right)$$

$$a' = \frac{17a}{x}(\text{mm})$$

$$\textit{receptor density} \approx \frac{1}{(a')^2}\left(\frac{1}{\text{mm}^2}\right)$$

$$d'_1 = 17\frac{d}{x_1}(\text{mm}) \qquad d'_2 = 17\frac{d}{x_2}(\text{mm})$$

POLARIMETRY

$$\alpha = [\alpha]_D^{20} \cdot c \cdot l$$

$$\alpha = \sum \alpha_i$$

$$\alpha = \Delta n \cdot l \cdot \pi / \lambda$$

SKIN IMPEDANCE

$$I = I_{\max}\sin(2\pi \cdot f \cdot t)$$

$$U = U_{\max}\sin(2\pi \cdot f \cdot t)$$

$$I_{rms} = \frac{I_{\max}}{\sqrt{2}}$$

$$U_{rms} = \frac{U_{\max}}{\sqrt{2}}$$

$$R = \frac{U_{gen}}{I}$$

$$Z = \frac{U_{\text{rms}}}{I_{\text{rms}}}$$

$$R = \rho \frac{l}{A}$$

$$\rho^* = RA$$

$$C = \varepsilon \frac{A}{l}$$

$$X_C = \frac{1}{2\pi f C}$$

$$\gamma^* = \frac{C}{A}$$

$$U_{gen} = U_{coarse} \cdot U_{fine} \cdot 5V$$

$$U_{gen.eff} = U_{coarse} \cdot U_{fine} \cdot 5V \cdot \frac{1}{\sqrt{2}}$$

$$|Z| = \frac{R}{\sqrt{1 + (2\pi f RC)^2}}$$

NUCLEAR MEDICINE

$$N_{\text{s}} = N_{\text{s+n}} - N_{\text{n}}$$

$$E_\gamma = A + E_e$$

$$E_\gamma = A + E_e + E_\gamma'$$

$$E_\gamma = 2m_e c^2 + E_e + E_p$$

GAMMA ABSORPTION

$$J = J_0 e^{-\mu \cdot x}$$

$$J = J_0 e^{-\mu_m \cdot x_m}$$

$$x_{1/10} = \frac{D}{\lg 2}$$

$$\mu = \frac{\ln 2}{D}$$

$$\mu = \mu_m \cdot \rho$$

$$x_m = x \cdot \rho$$

$$D_m = D \cdot \rho$$

$$\mu_m = \tau_m + \sigma_m + \kappa_m$$

II. SEMESTER

GAMMA ENERGY

$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{U_1}{U_2}$$

ISOTOPE DIAGNOSTICS

$$\frac{1}{T_{\text{eff}}} = \frac{1}{T_{\text{phys}}} + \frac{1}{T_{\text{biol}}}$$

$$\lambda_{eff} = \lambda_{phys} + \lambda_{biol}$$

DOSIMETRY

$$D = \frac{\Delta E}{\Delta m}$$

$$D_t = \frac{D}{t}$$

$$X = \frac{\Delta q}{\Delta m}$$

$$D = f_0 \cdot X$$

$$H_{\text{T}} = \sum_{\text{R}} D_{\text{T,R}} \cdot w_{\text{R}}$$

$$E = \sum_{T} H_T \cdot w_T$$

$$D_{air} = K_\gamma \frac{\Lambda t}{r^2}$$

$$U = \frac{Q}{C} \sim X$$

$$U = IR = \frac{Q}{t} R \sim \frac{X}{t}$$

$$X_t = \frac{I_{sat}}{m}$$

$$D_t = f_0 \cdot X_t$$

X-RAY

$$\varepsilon_{el} = \varepsilon_{kin} = \varepsilon_{photon} + Q = \varepsilon_{\text{photon, max}}$$

$$eU = h f_{max} = h \frac{c}{\lambda_{min}}$$

$$\lambda_{min} = \frac{h \cdot c}{e \cdot U} = \frac{k}{U}$$

$$P_{invested} = P_{useful} + P_{loss}$$

$$P_{el} = P_X + P_Q$$

$$P_X = c_X U^2 I Z$$

$$P_{in} = U I$$

$$\eta = P_X / P_{in} = c_X U Z$$

$$\tau_m = C \lambda^3 Z^3$$

$$\mu = \frac{1}{x} \ln\left(\frac{J_0}{J}\right)$$

$$\mu_m = \frac{\mu}{\rho}$$

$$\tau_m = \mu_m - 0{,}2 \frac{\text{cm}^2}{\text{g}}$$

$$P = \frac{\Delta E}{\Delta t}$$

$$P_Q = \frac{Q}{\Delta t}$$

$$J = \frac{P}{A}$$

$$A_{sphere} = 4 r^2 \pi$$

$$\sin \Theta = \frac{N\lambda}{2d}$$

CAT- SCAN

$$J = J_0 e^{-(\mu_1 \Delta x + \mu_2 \Delta x + \ldots \mu_n \Delta x)} = J_0 e^{-\sum_{i=1}^{n} \mu_i \Delta x}$$

$$D_i = \lg \frac{J_{i_0}}{J_i} = \lg e \cdot \sum_{j=1}^{n} \mu_{ij} \Delta x$$

$$D = \lg \frac{J_0}{J} = \sum_{i=1}^{n} D_i$$

$$HU = \frac{\mu - \mu_{water}}{\mu_{water}} 1000$$

AMPLIFIER

$$R = \frac{U}{I}$$

$$P = U \cdot I = \frac{U^2}{R} = I^2 \cdot R$$

$$U_1 = I \cdot R_1 = \frac{U_0}{R_1 + R_2} \cdot R_1 = const. \cdot R_1$$

$$A_P = \frac{P_{out}}{P_{in}}$$

$$A_U = \frac{U_{out}}{U_{in}}$$

$$A_P = \frac{U_{out}^2 / R_{out}}{U_{in}^2 / R_{in}} = A_U^2 \frac{R_{in}}{R_{out}} \approx A_U^2$$

$$n = 10 \cdot \lg A_P \ \text{(dB)}$$

$$n = 20 \cdot \lg A_U + 10 \cdot \lg \frac{R_{in}}{R_{out}} \approx 20 \log A_U \ \text{(dB)}$$

$$U = U_{in} - U_{out} \cdot \beta$$

$$U_{out} = (U_{in} - U_{out} \cdot \beta) \cdot A_U$$

$$A_{U,nf} = \frac{U_{out}}{U_{in}} = \frac{A_U}{1 + A_U \beta}$$

$$A_{U,nf} \cong \frac{1}{\beta}$$

$$U_{in,max} = U_{coarse} \cdot U_{fine} \cdot 5V$$

COULTER COUNTER

$$R = \rho \frac{l}{A}$$

$$U = I_{gen} \cdot R$$

$$h = \frac{c_{actual}}{c_{measured}} = \frac{c_{actual}}{n \cdot 10^4 / \mu l}$$

$$c_{actual} = h \cdot c_{measured} = h \cdot n \cdot 10^4$$

PULSE GENERATOR

$$I = \frac{\Delta Q}{\Delta t}$$

$$U = \Delta \phi = \frac{\Delta E}{\Delta Q}$$

$$R = \frac{U}{I}$$

$$P = \frac{\Delta E}{\Delta t}$$

$$P = U \cdot I = \frac{U^2}{R} = I^2 \cdot R$$

$$E_C = \frac{1}{2} C U^2$$

$$\tau = R \cdot C$$

$$T_{AMV} = \tau_1 + \tau_2$$

$$D = \frac{\tau_1}{\tau_1 + \tau_2} 100\%$$

$$f = \frac{1}{T}$$

$$U = U_{t=0} \cdot e^{-\frac{t}{RC}}$$

$$U = U_{t=\infty} \cdot \left(1 - e^{-\frac{t}{RC}}\right)$$

AUDIOMETRY

$$c = \lambda \cdot f = \frac{\lambda}{T}$$

$$p(t) = p_1 \cdot \sin(\omega t + \varphi)$$

$$Z = c\rho$$

$$J = \frac{P}{A}$$

$$J = \frac{{p_{eff}}^2}{Z}$$

$$R = \frac{J_{refl}}{J_0} = \left(\frac{Z_1 - Z_2}{Z_1 + Z_2}\right)^2$$

$$n_{octave} = \log_2 \frac{f_2}{f_1}$$

$$J_{dB} = 10 \lg \left(\frac{J}{J_0}\right)$$

$$H_{phon} = 10 \lg \left(\frac{J}{J_0}\right)_{1000 Hz}$$

$$H_{son} = \frac{1}{16} \left(\frac{J}{J_0}\right)_{1000 Hz}^{0,3}$$

$$H_{phon} + 10\, phon = H_{son} \cdot 2$$

$$D_{sound} = J_{sound} \cdot t$$

$$J = \eta \frac{U_{\mathrm{rms}}^{2}}{R}$$

$$U_{gen} = U_{coarse} \cdot U_{fine} \cdot 5V$$

$$J_{\mathrm{own}} = AU^2 \left(= 1 \cdot 10^{-5} \cdot U^2 (W/m^2)\right)$$

$$J_{dB,own} = 10 \lg \left(\frac{J_{own}}{J_0} \right)$$

$$HV = J_{dB,own} - J_{dB,norm}$$

SENSOR

$$\Psi_W = const. \log \frac{\Phi}{\Phi_0}$$

$$\Psi_S = const. \left(\frac{\Phi}{\Phi_0} \right)^n$$

$$H_{\mathrm{rel}} = const. \left(\frac{J}{J_0} \right)^n$$

ECG

$$U = \Delta \varphi = \frac{\Delta E}{\Delta q}$$

$$U_{TM} = \varphi_{\mathrm{intracell}} - \varphi_{\mathrm{extracell}}$$

$$U_{\mathrm{out}} = (U_{in_1} - U_{in_2}) A_U$$

$$U_{\mathrm{I}} = \varphi_{\mathrm{L}} - \varphi_{\mathrm{R}} = U_{frontal} \cdot \cos(0^\circ - \alpha) = U_{frontal} \cdot \cos(\alpha)$$

$$U_{\mathrm{II}} = \varphi_{\mathrm{F}} - \varphi = U_{frontal} \cdot \cos(60^\circ - \alpha)$$

$$U_{\mathrm{III}} = \varphi_{\mathrm{F}} - \varphi_{\mathrm{L}} = U_{frontal} \cdot \cos(120^\circ - \alpha)$$

$$U_{\mathrm{II}} = U_I + U_{III}$$

$$\phi_{\mathrm{CT}} = (\phi_{\mathrm{L}} + \phi_{\mathrm{R}} + \phi_{\mathrm{F}})/3 = 0$$

$$U_{\mathrm{Vi}} = \phi_{\mathrm{C}i} - (\phi_{\mathrm{L}} + \phi_{\mathrm{R}} + \phi_{\mathrm{F}})/3$$

$$U_{\mathrm{aVR}} = \phi_{\mathrm{R}} - (\phi_{\mathrm{L}} + \phi_{\mathrm{F}})/2$$

$$U_{\mathrm{aVL}} = \phi_{\mathrm{L}} - (\phi_{\mathrm{R}} + \phi_{\mathrm{F}})/2$$

$$U_{\mathrm{aVF}} = \phi_{\mathrm{F}} - (\phi_{\mathrm{R}} + \phi_{\mathrm{L}})/2$$

$$\sin(\alpha \pm \beta) = \sin \alpha \cos \beta \pm \cos \alpha \sin \beta$$

$$\cos(\alpha \pm \beta) = \cos \alpha \cos \beta \mp \sin \alpha \sin \beta$$

FLOW

$$I_{\mathrm{V}} = \frac{\Delta V}{\Delta t}$$

$$I_{\mathrm{V}} = \frac{A \cdot \overline{\Delta l}}{\Delta t} = A \cdot \bar{v}$$

$$A_1 \cdot \overline{v_1} = A_2 \cdot \overline{v_2} = const.$$

$$I_V = -\frac{\pi}{8\eta} r^4 \frac{\Delta p}{\Delta l}$$

$$\mathrm{Re} = \frac{\bar{v} \cdot \rho \cdot r}{\eta}$$

$$v_{\mathrm{crit}} = 1160 \frac{\eta}{\rho \cdot r}$$

$$\eta = \frac{\pi}{8} \frac{r^4}{\Delta V} \frac{\overline{\Delta h} \rho g}{l} \Delta t$$

$$\Delta p = R_{\mathrm{tube}} I_V \qquad (U = RI)$$

$$R_{\mathrm{tube}} = 8 \pi \eta \frac{l}{A^2}$$

$$R = \frac{U}{I}$$

$$R_{\mathrm{parallel,\,res}} = \frac{R}{n}$$

$$I_B = \frac{I_A}{n}$$

$$I_C = \frac{I_A}{m}$$

DIFFUSION

$$J_v = \frac{\Delta \nu}{\Delta t \Delta A}$$

$$J_v = -D \cdot \frac{\Delta c}{\Delta x}$$

$$D = \frac{kT}{6\pi\eta r_{Stokes}}$$

D = 1.38 *10^{-8} m^2/mm^2*$slope^2$

$$D \cdot \frac{\Delta\left(\frac{\Delta c}{\Delta x}\right)}{\Delta x} = \frac{\Delta c}{\Delta t}$$

$$w = 6 \cdot \sqrt{2 \cdot D \cdot t}$$

$$R_{average} = \sqrt{6 \cdot D \cdot t}$$

THEORY

I. THE MAIN PROPERTIES OF „LIVING" MATTER AND THEIR ROLE IN BIOLOGICAL FUNCTIONS

$$hf = E_m - E_i \qquad \text{(I.1)}$$

$$\lambda = \frac{h}{p} = \frac{h}{m\upsilon} \qquad \text{(I.3)}$$

$$\Delta M = [Z \cdot m_p + (A - Z) \cdot m_n] - M(A, Z) \qquad \text{(I.19)}$$

$$E = mc^2$$

$$n_i = n_0 e^{-\frac{\varepsilon_i - \varepsilon_0}{kT}} \qquad R = N_A k \qquad \text{(I.25)}$$

$$\frac{n_{(h)}}{n_{(0)}} = e^{-\frac{mgh}{kT}} \qquad \text{(I.26)}$$

$$\frac{n_A}{n_B} = e^{-\frac{qU}{kT}} \qquad \text{(I.28)}$$

$$\bar{\varepsilon}_{kinetic} = \frac{1}{2} m\overline{\upsilon^2} = \frac{3}{2} kT \qquad \text{(I.34)}$$

$$pV = NkT \qquad \text{(I.35)}$$

$$pV = nRT$$

$$p = \frac{NkT}{V - Nb} - an^2 \qquad \text{(I.36)}$$

$$\left(p + a\frac{N^2}{V^2}\right)(V - Nb) = nkT \qquad \text{(I.37)}$$

$$\sigma = const \cdot e^{-\frac{\Delta\varepsilon}{2kT}} \qquad \text{(I.39)}$$

$$n_S \cong N \cdot e^{-\frac{\varepsilon_S}{kT}} \qquad \text{(I.40)}$$

$$c = \frac{\Delta Q}{m \cdot \Delta T}$$

$$L_m = \frac{\Delta Q_{melting}}{m}$$

$$L_v = \frac{\Delta Q_{vaporization}}{m}$$

$$n = \frac{c_{\text{vacuum}}}{c_{\text{medium}}}$$

$$M = \frac{I}{O} = \frac{i}{o}$$

$$M_{\text{angle}} = -\frac{da}{f_{eyepiece} f_{objective}}$$

$$f = \frac{1}{T}$$

$$c = f\lambda$$

$$\Delta s = d \sin \alpha_{\text{k}} = \text{k}\lambda$$

$$P = \frac{\Delta E}{\Delta t} \quad \text{(II.1)}$$

$$M = \frac{\Delta P}{\Delta A} \quad \text{(II.2)}$$

$$M_{\lambda} = \frac{\Delta M}{\Delta \lambda}$$

$$E_{\text{in}} = \frac{\Delta P}{\Delta A} \qquad \sim \frac{1}{r^2}, \sim \frac{1}{r} \quad \text{(II.3)}$$

$$I_E = \frac{\Delta E}{\Delta t} \quad \text{(II.4)}$$

$$J_E = \frac{\Delta E}{\Delta t \Delta A} \quad \text{(II.5)}$$

$$E_{in} = E_{in,\max} \cdot \cos \alpha \quad \text{(II.8)}$$

$$\Delta J = -\mu \Delta x J \quad \text{(II.10)}$$

$$J = J_0 \mathrm{e}^{-\mu x} \quad \text{(II.11)}$$

$$\mu = \frac{1}{\delta}$$

$$J = J_0 2^{-\frac{x}{D}} \quad \text{(II.12)}$$

$$\mu = \frac{\ln 2}{D} \quad \text{(II.13)}$$

$$\frac{\sin \alpha}{\sin \beta} = \frac{c_1}{c_2} = n_{21} \quad \text{(II.14)}$$

$$D = \frac{n_2 - n_1}{r} \quad \text{(II.17)}$$

$$D = D_1 + D_2 \quad \text{(II.21)}$$

$$\frac{1}{f} = D = \frac{1}{o} + \frac{1}{i} \quad \text{(II.22)}$$

$$D = \frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right) \quad \text{(II.23)}$$

$$c = \frac{\lambda}{T}, \quad \text{illetve} \quad c = \lambda f \quad \text{(II.26)}$$

$$J \sim A^2 \quad \text{(II.27)}$$

$$J_1 + J_2 \neq J_{\text{res}} \quad \text{(II.28)}$$

$$A_{res}^2 = 2A^2(1 + \cos \Delta\varphi) \quad \text{(II.31)}$$

$$\Delta s = d \sin \alpha \quad \text{(II.32)}$$

$$\Delta x \approx \Delta s \frac{L}{d} \quad \text{(II.33)}$$

$$\Delta \varphi = \Delta s \frac{2\pi}{\lambda} \quad \text{(II.34)}$$

$$d \approx \lambda \frac{L}{d} \quad \text{(II.36)}$$

$$E_{\text{kin}} = hf - W_{\text{em}} \quad \text{(II.37)}$$

$$E = E_{\text{kinetic}} + E_{\text{electron}} + E_{\text{vibration}} + E_{\text{rotation}}$$

$$p = mc = \frac{hf}{c} = \frac{h}{\lambda} \quad \text{(II.38)}$$

$$\frac{M_{\lambda_{\text{i}}}}{\alpha_{\lambda_{\text{i}}}} = \frac{M_{\lambda_{\text{j}}}}{\alpha_{\lambda_{\text{j}}}} \quad \text{(II.39)}$$

$$M_{\text{black}}(T) = \sigma T^4 \quad \text{(II.41)}$$

$$\Delta M = \sigma(T_{\text{body}}^4 - T_{\text{environment}}^4)$$

$$\Delta E = \sigma(T_{\text{body}}^4 - T_{\text{environment}}^4) \cdot A \cdot t$$

$$\lambda_{\max} T = \text{const.} \quad \text{(II.42)}$$

$$\Delta N_a = K_1 B_{12} N_1 J' \Delta t \quad \text{(II.44)}$$

$$\Delta N_{se} = K_1 A N_2 \Delta t \quad \text{(II.45)}$$

$$\Delta N_{ie} = K_1 B_{21} N_2 J' \Delta t \quad \text{(II.46)}$$

$$\Delta J = JK(N_2 - N_1) \quad \text{(II.54)}$$

$$\mu = K(N_1 - N_2) \quad \text{(II.56)}$$

$$2L = m\lambda \quad \text{(II.57)}$$

$$J = J_0\, e^{-\frac{t}{\tau}}$$

$$\rho(\lambda) = \frac{J_{reflected}(\lambda)}{J_0(\lambda)}$$

$$\rho(\lambda) = \left(\frac{n_2 - n_1}{n_2 + n_1}\right)^2$$

$$\sigma(\lambda) = \frac{J_{\text{scattered}}(\lambda)}{J_0(\lambda)}$$

$$\sigma(\lambda) \sim \frac{\mathrm{d}^6}{\lambda^4}$$

$$J_{scattered,\lambda} = J_0 \frac{8\pi^4 N\alpha^2}{\lambda^4 R^2}\left(1 + \cos^2(\beta)\right)$$

$$P_{\text{scattered}} \sim \frac{{p_0}^2}{c^3}\omega^4 \sim \frac{1}{\lambda^4} \quad \text{(II.60)}$$

$$\alpha(\lambda) = \frac{J_{absorbed}(\lambda)}{J_0(\lambda)}$$

$$J = J_0\, e^{-a \cdot x}$$

$$a = \frac{1}{\delta}$$

$$a = \frac{\ln 2}{D}$$

$$A = \lg\left(\frac{J_0}{J}\right)$$

$$A = \varepsilon(\lambda) \cdot c \cdot x$$

$$\tau(\lambda) = \frac{J_{\text{transmitted}}(\lambda)}{J_0(\lambda)}$$

$$\rho(\lambda) + \sigma(\lambda) + \alpha(\lambda) + \tau(\lambda) = 1$$

$$\alpha = [\alpha]_D^{20} \cdot c \cdot l$$

$$D = E \cdot t$$

$$H = E \cdot t \cdot S$$

$$2L = m \cdot \lambda$$

$$\kappa = \frac{-\frac{\Delta V}{V}}{\Delta p} \quad \text{(II.63)}$$

$$c = \frac{1}{\sqrt{\rho\kappa}} \quad \text{(II.64)}$$

$$Z = c\rho \quad \text{(II.67)}$$

$$Z = \sqrt{\frac{\rho}{\kappa}} \quad \text{(II.68)}$$

$$R = \frac{J_R}{J_0} \quad \text{(II.76)}$$

$$R = \left(\frac{Z_1 - Z_2}{Z_1 + Z_2}\right)^2 \quad \text{(II.77)}$$

$$Z_{connecting} \approx \sqrt{Z_{source} \cdot Z_{skin}} \quad \text{(II.78)}$$

$$eU_{\text{anode}} = \varepsilon_{\max} = hf_{\max} \quad \text{(II.79)}$$

$$\lambda_{\min} = \frac{hc}{eU_{\text{anode}}} \quad \text{(II.80)}$$

$$P_{\text{X}} = c_{\text{X}} {U_{\text{anode}}}^2 Z I_{\text{anode}} = \eta U_{\text{anode}} I_{\text{anode}} \quad \text{(II.82)}$$

$$\eta = \frac{P_{emitted}}{P_{invested}} = c_{\text{X}} \cdot U_{anode} \cdot Z \quad \text{(II.83)}$$

$$J = J_0\, e^{-\mu \cdot x} \quad \text{(II.84)}$$

$$\mu = \mu_m \rho \qquad x_m = \rho x \tag{II.85}$$

$$\tau = \tau_m \rho \qquad \sigma = \sigma_m \rho \qquad \kappa = \kappa_m \rho$$

$$\varepsilon = hf = E_{\text{binding}} + E_{\text{kinetic}} \tag{II.86}$$

$$\tau_m = \frac{\tau}{\rho} = C_{\text{photo}} \lambda^3 Z^3 \tag{II.87}$$

$$Z_{eff} = \sqrt[3]{\sum_{i=1}^{n} w_i Z_i^3} \tag{II.88}$$

$$hf = E_{\text{binding}} + hf' + E_{\text{kinetic}} \tag{II.89}$$

$$\frac{\Delta N}{\Delta t} = -\lambda N \tag{II.95}$$

$$N = N_0 \mathrm{e}^{-\lambda t} \qquad \lambda = \frac{1}{\tau} \tag{II.96}$$

$$\frac{N_0}{2} = N_0 \mathrm{e}^{-\lambda T} \tag{II.97}$$

$$\lambda T = \ln 2 \tag{II.98}$$

$$\frac{1}{T_{\text{eff}}} = \frac{1}{T_{\text{phys}}} + \frac{1}{T_{\text{biol}}}$$

$$\lambda_{eff} = \lambda_{phys} + \lambda_{biol}$$

$$\Lambda = -\frac{\Delta N}{\Delta t} \tag{II.99}$$

$$\Lambda = \Lambda_0 \mathrm{e}^{-\lambda t} \tag{II.101}$$

$$s = \frac{\Delta E}{\Delta x}$$

$$s = s_m \rho$$

$$\mu = \tau + \sigma + \kappa \tag{II.102}$$

$$\mu_m = \tau_m + \sigma_m + \kappa_m$$

$$E_\gamma = A + E_{\text{e,kin}}$$

$$E_\gamma = A + E_{\text{e,kin}} + E_\gamma'$$

$$E_\gamma = hf = 2m_{\text{e}} c^2 + E_{\text{e,kin}} + E_{p,kin} \tag{II.103}$$

$$qvB = \frac{mv^2}{r}$$

$$D = \frac{\Delta E}{\Delta m} \tag{II.105}$$

$$D_{\text{air}} = K_\gamma \frac{\Lambda t}{r^2}$$

$$X = \frac{\Delta Q}{\Delta m} \tag{II.106}$$

$$D_{\text{air}} = f_0 X \tag{II.107}$$

$$D \sim \mu_m J, \quad \text{and} \quad D \sim s_m$$

$$H_{\text{T}} = \sum_{\text{R}} w_{\text{R}} D_{\text{TR}} \tag{II.108}$$

$$\sum_{\text{T}} w_{\text{T}} = 1 \tag{II.109}$$

$$E = \sum_{\text{T}} w_{\text{T}} H_{\text{T}} \tag{II.110}$$

$$S = \sum_{\text{i}} N_{\text{i}} E_{\text{i}} \tag{II.111}$$

$$S_T = \sum_{\text{i}} N_{\text{i}} H_{\text{T,i}} \tag{II.112}$$

$$I_V = \frac{\Delta V}{\Delta t} \quad \text{(III.1)}$$

$$I_V = A\bar{\upsilon} = \text{const.} \quad \text{(III.4)}$$

$$p + \frac{1}{2}\rho\upsilon^2 + \rho g h = const. \quad \text{(III.5)}$$

$$F = \eta A \frac{\Delta\upsilon}{\Delta h} \quad \text{(III.6)}$$

$$\eta = \frac{\tau}{D}$$

$$I_V = -\frac{\pi}{8\eta} R^4 \frac{\Delta p}{\Delta l} \quad \text{(III.12)}$$

$$R_{\text{tube}} = 8\pi\eta \frac{\Delta l}{(r^2\pi)^2} \quad \text{(III.14)}$$

$$\text{Re} = \frac{\bar{v}\cdot\rho\cdot r}{\eta}$$

$$\upsilon_{\text{crit}} = \text{Re}\frac{\eta}{\rho r} \quad \text{(III.17)}$$

$$\sigma_\theta = \frac{P\cdot r}{t} = \frac{F}{t\cdot l}$$

$$C = \frac{\Delta V}{\Delta P}$$

$$\Delta p = \frac{2\gamma}{R}$$

$$p_{total} = \sum_{i=1}^{n} p_i$$

$$p = k_H c$$

$$F = 6\pi\eta r\upsilon \quad \text{(III.18)}$$

$$u = \frac{\upsilon}{F} = \frac{1}{6\pi\eta r} \quad \text{(III.19)}$$

$$v_{mean} = \sqrt{\frac{3kT}{m}} \quad \text{(III.24)}$$

$$l = \bar{\upsilon}\tau \quad \text{(III.25)}$$

$$\upsilon_{\text{drift}} = \frac{F}{m}\tau \quad \text{(III.26)}$$

$$I_N = \frac{\Delta N}{\Delta t} \quad \text{(III.28)}$$

$$I_\nu = \frac{\Delta\nu}{\Delta t} \quad \text{(III.29)}$$

$$J_\nu = \frac{\Delta I_\nu}{\Delta A} \quad \text{(III.30)}$$

$$J_\nu = -D\frac{\Delta c}{\Delta x} \quad \text{(III.31)}$$

$$D = \frac{1}{3}\upsilon l = ukT \quad \text{(III.33)}$$

$$D = \frac{k\cdot T}{6\cdot\pi\cdot\eta\cdot r} \quad \text{(III.34)}$$

$$-\frac{\Delta J_\nu}{\Delta x} = \frac{\Delta c}{\Delta t} \quad \text{(III.38)}$$

$$D\frac{\Delta\left(\frac{\Delta c}{\Delta x}\right)}{\Delta x} = \frac{\Delta c}{\Delta t} \quad \text{(III.39)}$$

$$\sigma_x \sim \overline{R(t)} \sim \sqrt{Dt} \quad \text{(III.40)}$$

$$\overline{R(t)} = \sqrt{Nl^2} = \sqrt{3Dt}$$

$$p_{\text{osmosis}} = cRT \quad \text{(III.50)}$$

$$osm. = \sum\left(\varphi_i n_i c_i\right)$$

$$J_\nu = -L_T\frac{\Delta T}{\Delta x} \quad \text{(III.51)}$$

$$J_E = -\lambda\frac{\Delta T}{\Delta x} \quad \text{(III.53)}$$

$$J = LX \qquad J = \frac{\Delta x_{\text{ext}}}{A\Delta t} \qquad X = -\frac{\Delta y_{\text{int}}}{\Delta x} \quad \text{(III.54)}$$

$$\Delta E = Q_E + W \qquad Q_E = cm\Delta T \quad \text{(III.56)}$$

$$W_V = -p\Delta V \quad W_Q = \varphi\Delta Q \quad W_\nu = \mu\Delta\nu \quad \text{(III.58)}$$

$$W^{(i)} = y_{int}{}^{(i)}\Delta x_{ext}{}^{(i)} \quad \text{(III.59)}$$

$$W_{\nu Q} = W_\nu + W_Q = (\mu + zF\varphi)\Delta\nu = \mu_e\Delta\nu \quad \text{(III.61)}$$

$$Q_E = T\Delta S \quad \text{(III.63)}$$

$$\Delta E = \sum_{(i)} y_{int}{}^{(i)}\Delta x_{ext}{}^{(i)} \quad \text{(III.64)}$$

$$W_{mech} = -n \cdot R \cdot T \cdot \ln\frac{V_2}{V_1}$$

$$W_{chem} = -n \cdot R \cdot T \cdot \ln\frac{c_2}{c_1}$$

$$\Delta S = c \cdot m \cdot \ln\frac{T_2}{T_1}$$

$$\Delta S = \frac{\Delta E_1}{T_1} + \frac{\Delta E_2}{T_2} = \Delta E\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \quad \text{(III.67)}$$

$$S = k\ln\Omega \quad \text{(III.72)}$$

$$\frac{P_i}{P_j} = \frac{\Omega_i}{\Omega_j} = \frac{e^{\frac{S_i}{k}}}{e^{\frac{S_j}{k}}} = e^{\frac{S_i - S_j}{k}} \quad \text{(III.74)}$$

$$\Delta U = T\Delta S - p\Delta V + \sum_{i=1}^{n}\mu_i\Delta\nu_i + \varphi\Delta q + A\Delta\xi$$

$$E = TS - pV + \mu\nu \quad \text{(III.83)}$$

$$H = E + pV \quad \text{(III.84)}$$

$$\Delta H_p = Q_E + W_\nu \quad \text{(III.87)}$$

$$\Delta H_{p,\nu} = Q_E \quad \text{(III.88)}$$

$$F = E - TS \quad \text{(III.89)}$$

$$\Delta F_T = W_V + W_\nu \quad \text{(III.91)}$$

$$\Delta F_{T,\nu} = W_V \quad \text{(III.92)}$$

$$\Delta F_{T,V} = W_\nu \quad \text{(III.93)}$$

$$G = H - TS \quad \text{(III.94)}$$

$$\Delta G_{T,p} = W_\nu \quad \text{(III.96)}$$

$$\Delta G_{T,p} \le 0 \quad \text{(III.99)}$$

$$\Delta F_{T,V} \le 0 \quad \text{(III.100)}$$

$$\Delta H_{S,p} \le 0 \quad \text{(III.101)}$$

$$G = \mu_A\nu_A + \mu_B\nu_B \quad \text{(III.105)}$$

$$\mu_A = \mu^0{}_A + RT\ln(c_A) \quad \text{(III.109)}$$

$$\mu^e = \mu + ZF\varphi$$

$$J_m = -p(c_{v_2} - c_{v_1}) \quad \text{(III.113)}$$

$$p = \frac{D}{d}$$

$$J_k = -L_k\frac{\Delta\mu_e}{\Delta x} \quad \text{(III.116)}$$

$$L_k = c_k\frac{D_k}{RT} = \frac{c_k u_k}{N_A} \quad \text{(III.118)}$$

$$J_k = -D_k\left(\frac{\Delta c_k}{\Delta x} + c_k\frac{z_k F}{RT}\frac{\Delta\varphi}{\Delta x}\right) \quad \text{(III.119)}$$

$$U = \frac{RT}{F}\ln\frac{\sum_{k=1}^{m} p_k^+ c_{k,II}^+ + \sum_{k=1}^{n} p_k^- c_{k,I}^-}{\sum_{k=1}^{m} p_k^+ c_{k,I}^+ + \sum_{k=1}^{n} p_k^- c_{k,II}^-} \quad \text{(III.121)}$$

$$U = \varphi^{II} - \varphi^{I} = \frac{RT}{z_i F}\ln\frac{c_i^I}{c_i^{II}} \quad \text{(III.123)}$$

$$U_m(t) = U_t\left(1 - e^{-\frac{t}{R_m C_m}}\right) \quad \text{(III.130)}$$

$$\tau = R_m C_m \quad \text{(III.131)}$$

$$\lambda \approx \sqrt{\frac{R_m}{R_i + R_e}} \approx \sqrt{\frac{R_m}{R_i}}$$

$$U_m(t) = U_t e^{-\frac{t}{R_m C_m}} \quad \text{(III.132)}$$

$$U_m(x) - U_m(0) = U_t e^{-\frac{x}{\lambda}} \quad \text{(III.133)}$$

IV. BIOPHYSICS OF THE SENSES

$$\Psi_W = const.\log\frac{\Phi}{\Phi_0} \quad \text{(IV.6)}$$

$$\Psi_S = const.\left(\frac{\Phi}{\Phi_0}\right)^n \quad \text{(IV.8)}$$

$$P = J\cdot\pi\cdot\left(\frac{d}{2}\right)^2 \quad \text{(IV.9)}$$

$$\frac{P_{\max}}{P_{\min}} = \left(\frac{d_{\max}}{d_{\min}}\right)^2 = 16 \quad \text{(IV.10)}$$

$$D = \frac{n-n'}{r} \quad \text{(IV.11)}$$

$$D = \frac{n_t}{o} + \frac{n_k}{i} \quad \text{(IV.12)}$$

$$\text{visus} = \frac{1(')}{\alpha(')}100\% \quad \text{(IV.14)}$$

$$\alpha_H = 1{,}22\cdot\frac{\lambda}{d} \quad \text{(IV.15)}$$

$$A = \frac{E_{ion}}{E_{photon}} = \frac{ne\Delta\varphi}{hf}$$

$$X = rR + gG + bB$$

$$n_{\text{octave}} = \log_2\frac{f_2}{f_1} \quad \text{(IV.22)}$$

$$p(t) = p_{\max}\cdot\sin(\omega t+\varphi) \quad \text{(IV.23)}$$

$$R = \frac{J_{\text{refl}}}{J_0} = \left(\frac{Z_1-Z_2}{Z_1+Z_2}\right)^2$$

$$F_{drum} = p_{air}\cdot A_{drum}$$

$$n = 10\lg\left(\frac{P_{\text{out}}}{P_{\text{in}}}\right) = 10\lg\left(\frac{J_{\text{out}}}{J_{\text{in}}}\right) \quad \text{(IV.26)}$$

$$n = n_{\text{amp}} + n_{\text{damp}} \quad \text{(IV.27)}$$

$$n = 10\lg\left(\frac{J}{J_0}\right) \quad \text{(IV.28)}$$

$$H_{\text{phon}} = 10\lg\left(\frac{J}{J_0}\right)_{1000\,Hz} \quad \text{(IV.29)}$$

$$H_{\text{son}} = \frac{1}{16}\left(\frac{J}{J_0}\right)^{0{,}3}_{1000\,Hz} \quad \text{(IV.31)}$$

$$H_{phon} + 10\,phon = H_{son}\cdot 2$$

V. BIOMECHANICS

$$\frac{F}{A} = E\frac{\Delta L}{L} \quad \text{(V.1)}$$

$$\sigma = \frac{F}{A}$$

$$\varepsilon = \frac{\Delta L}{L}$$

$$E = \frac{\sigma}{\varepsilon}$$

$$c_{sound} = \frac{1}{\sqrt{\rho\cdot\kappa}}$$

$$\kappa = \frac{-\Delta V/V}{\Delta p}$$

$$\sigma = \eta\frac{\Delta\varepsilon}{\Delta t}$$

$$\left(R^2\right)_{mean} = 2L_pL \quad \text{(V.3)}$$

$$r=\frac{\tau_{on}}{\tau_{on}+\tau_{off}}=\frac{\tau_{on}}{\tau_{total}} \quad \text{(V.4)}$$

$$v_{stroke}=\frac{\delta}{\tau_{on}}$$

$$\tau_{total}=\frac{1}{k_{ATPase}}$$

$$r=\frac{\delta\cdot k_{ATPase}}{v_{stroke}}$$

$$P=Fv \quad \text{(V.5)}$$

$$(F+a)(v+b)=(F_0+a)b$$

$$v_{\max}=\frac{bF_0}{a}$$

$$\frac{\Delta L}{L}=\alpha\cdot\Delta T$$

$$\frac{\Delta V}{V}=\beta\cdot\Delta T$$

VI. PHYSICAL METHODS IN MOLECULAR AND CELLULAR DIAGNOSTICS

$$M_{\text{angle}}=\frac{\text{tg}\,\beta}{\text{tg}\,\alpha}=a\left(\frac{1}{f}-\frac{1}{i}\right) \quad \text{(VI.18)}$$

$$M_{i=\infty}=-\frac{a}{f} \quad \text{(VI.20)}$$

$$M_{\text{angle}}=-\frac{da}{f_1 f_2} \quad \text{(VI.23)}$$

$$\Delta s=d\sin\alpha_{\text{k}}=\text{k}\lambda \quad \text{(VI.24)}$$

$$\delta=0.61\frac{\lambda}{n\sin\omega} \qquad f=\frac{1}{\delta} \quad \text{(VI.28)}$$

$$J=J_0\,e^{-\mu\cdot x} \quad \text{(VI.29)}$$

$$T=\frac{J}{J_0}(100\%) \quad \text{(VI.33)}$$

$$A=\lg\left(\frac{J_0}{J}\right)=\varepsilon(\lambda)cx \quad \text{(VI.34)}$$

$$Q_F=\frac{k_f}{k_f+k_{nr}}=\frac{k_f}{k_f+k_{ic}+k_{isc}+k_Q} \quad \text{(VI.36)}$$

$$Q_{ST}=\frac{k_{isc}}{k_f+k_{nr}}$$

$$Q_{ph}=Q_{ST}\frac{k_{ph}}{k_{ph}+k_{nr,ph}} \quad \text{(VI.37)}$$

$$\Delta N=-(k_f+k_{nr})\cdot N\cdot\Delta t \quad \text{(VI.38)}$$

$$N=N_0\text{e}^{-(k_\text{f}+k_\text{nr})t} \quad \text{(VI.39)}$$

$$\tau=\frac{1}{k_\text{f}+k_\text{nr}} \quad \text{(VI.40)}$$

$$Q_\text{f}=k_\text{f}\tau \quad \text{(VI.41)}$$

$$p=\frac{J_{\text{VV}}-J_{\text{VH}}}{J_{\text{VV}}+J_{\text{VH}}} \quad \text{(VI.43)}$$

$$D=\frac{w^2}{4t_D}$$

$$F = k\frac{Q_1Q_2}{r^2}$$

$$E = \frac{F}{q}$$

$$U_{21} = \frac{W_{1\to2}}{q} \qquad \phi_i = \frac{W_{0\to i}}{q}$$

$$U_{21} = E \cdot s$$

$$C = \frac{Q}{U}$$

$$C = \varepsilon_0\varepsilon_r\frac{A}{l}$$

$$W == \frac{1}{2}UQ = \frac{1}{2}CU^2 = \frac{1}{2}\frac{Q^2}{C}$$

$$C_{parallel,res} = C_1 + C_2$$

$$\frac{1}{C_{series,res}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$I = \frac{\Delta Q}{\Delta t}$$

$$J = \frac{\Delta Q}{A \cdot \Delta t}$$

$$R = \frac{U}{I}$$

$$G = \frac{1}{R} = \frac{I}{U}$$

$$R = \rho\frac{l}{A}$$

$$\sigma = \frac{1}{\rho}$$

$$R_{series,res} = R_1 + R_2$$

$$\frac{1}{R_{parallel,res}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$W = U \cdot I \cdot t$$

$$P = U \cdot I = \frac{U^2}{R} = I^2 \cdot R$$

$$U_R = U_B e^{-\frac{t}{RC}} \quad U_C = U_B\left(1 - e^{-\frac{t}{RC}}\right) \quad \text{(VII.2)}$$

$$I = I_{max}\sin(2\pi \cdot f \cdot t)$$

$$U = U_{max}\sin(2\pi \cdot f \cdot t)$$

$$I_{rms} = \frac{I_{max}}{\sqrt{2}}$$

$$U_{rms} = \frac{U_{max}}{\sqrt{2}}$$

$$P = U_{rms} \cdot I_{rms}$$

$$Z = \frac{U_{rms}}{I_{rms}}$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{\omega C} \quad \text{(VII.4)}$$

$$U_{out} = U_{in}\frac{R}{\sqrt{R^2 + X_C^2}} \quad \text{(VII.5)}$$

$$U_{out,low\text{-}cut} = U_{be}\frac{RC\omega}{\sqrt{1 + C^2R^2\omega^2}}$$

$$U_{out,high\text{-}cut} = U_{be}\frac{1}{\sqrt{1 + C^2R^2\omega^2}}$$

$$f_0 = \frac{1}{2\pi RC}$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$A_U = \frac{U_{\text{out}}}{U_{\text{in}}} \qquad A_P = \frac{P_{\text{out}}}{P_{\text{in}}} \tag{VII.6}$$

$$A_P = A_U^{\,2} \quad \text{ha } R_{out} = R_{\text{in}} \tag{VII.8}$$

$$n = 10\lg A_P = 20\lg A_U \tag{VII.10}$$

$$U_{out} = \frac{R_2}{R_1 + R_2} \cdot U_{in}$$

$$U_{\text{out}} = (U_{\text{in}_1} - U_{\text{in}_2}) A_U \tag{VII.11}$$

$$A_{U,V^+} = \frac{A_U}{1 - A_U \beta}$$

$$A_{U,V^-} = \frac{A_U}{1 + A_U \beta} \tag{VII.14}$$

$$\beta = \frac{U_{back}}{U_{out}}$$

$$H = \sum_i p_i \cdot \log_2 \frac{1}{p_i}$$

VIII. MEDICAL IMAGING METHODS

$$J = J_0 e^{-(\mu_1 \Delta x + \mu_2 \Delta x + \ldots \mu_n \Delta x)} = J_0 e^{-\sum_{i=1}^{n} \mu_i \Delta x}$$

$$\lg \frac{J_0}{J} = (\mu_1 x_1 + \mu_2 x_2 + \ldots) \lg \mathrm{e} \tag{VIII.2}$$

$$hf_0 = g_{\mathrm{N}} \mu_{\mathrm{N}} H_0 \tag{VIII.3}$$

$$M_{long}(t) = M_{long}(0) \cdot \left(1 - e^{-\frac{t}{T_1}}\right)$$

$$M_{trans}(t) = M_{trans}(0) \cdot e^{-\frac{t}{T_2}}$$

$$P = d \times \frac{F}{A}$$

$$\frac{\Delta l}{l} = E \times d$$

$$c = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{1}{\kappa \rho}}$$

$$f' = f\left(1 \pm \frac{\upsilon}{c}\right) \tag{VIII.4}$$

$$f_{\mathrm{D}} = f' - f = \frac{\pm \upsilon}{c} f \qquad f_{\mathrm{D}} = \frac{\pm 2\upsilon}{c} f \tag{VIII.5}$$

$$HU = \frac{\mu - \mu_{\text{water}}}{\mu_{\text{water}}} 1000 \tag{VIII.10}$$

IX. THE PHYSICAL BASIS OF THERAPEUTIC METHODS

$$a_{\text{threshold}} = \frac{q}{\tau} + r$$

$$2r = \frac{q}{C} + r$$

$$k_t = \frac{1}{\tau_D} \frac{R_0^6}{R^6} \quad \text{(X.6)}$$

$$2d \sin\theta = n \cdot \lambda$$

$$\vec{F}_{el} = \vec{E} \cdot q$$

$$\vec{F}_{magn} = q \cdot \vec{v} \times \vec{B}$$

$$\vec{F}_{cp} = m \cdot \frac{\vec{v}^2}{r}$$

$$\frac{m}{q} = \frac{\vec{E} + \vec{v} \times \vec{B}}{\vec{a}}$$

$$r_{el} = \frac{mv^2}{Eq}$$

$$r_m = \frac{1}{B} \sqrt{\frac{2mU}{q}}$$

$$t = \frac{d}{\sqrt{2U}} \sqrt{\frac{m}{q}}$$

$$L = \sqrt{l(l+1)}\hbar \quad \text{(X.26)}$$

$$M_N = \gamma_N L = g_N \mu_N \sqrt{l(l+1)} \quad \text{(X.28)}$$

$$M_e = -g\mu_\beta \sqrt{S(S+1)} \quad \text{(X.29)}$$

$$\Delta E = hf_0 = g_N \mu_N H_0 \quad \text{(X.30)}$$

$$\Delta E = \frac{h\omega_0}{2\pi}$$

$$\omega_0 = \gamma B_0$$

$$f_{Larmor} = \frac{\gamma}{2\pi} B_0$$

$$\frac{N_\beta}{N_\alpha} = e^{-\frac{\Delta E}{kT}} \quad \text{(X.31)}$$

Universal gas constant	R = 8.314 J/(mol·K)
Avogadro's number	$N_A = 6 \cdot 10^{23}$ /mol
Boltzmann's constant	$k = 1.38 \cdot 10^{-23}$ J/K
Faraday's constant	F = 96500 C/mol
Planck's constant	$h = 6.626 \cdot 10^{-34}$ J·s
Speed of light (in vacuum)	$c = 3 \cdot 10^{8}$ m/s
Electron charge	$e = 1.6 \cdot 10^{-19}$ C
Mass of electron (in rest)	$m_e = 9.1 \cdot 10^{-31}$ kg
Mass of proton (in rest)	$m_p = 1.673 \cdot 10^{-27}$ kg
Mass of neutron (in rest)	$m_n = 1.675 \cdot 10^{-27}$ kg
Stefan-Boltzmann constant	$\sigma = 5.67 \cdot 10^{-8}$ J/(m²·K⁴·s)
Wien's displacement constant	$b = 2.898 \cdot 10^{-3}$ m·K
Gravitational acceleration	$g = 9.81$ m/s²
Reynolds number	Re = 1160
X-ray constant	$C_X = 1.1 \cdot 10^{-9}$ V⁻¹
g factor of proton	$g_p = 5.59$
Nuclear magneton	$\mu_N = 5.05 \cdot 10^{-27}$ J/T
Constant of photoeffect	$C_{photo} = 6$ cm²/(g·nm³)
Conversion factor for air	$f_0 = 34$ J/C
Coulomb's constant	$k = 9 \cdot 10^{9}$ Nm²/C²
Vacuum permittivity	$\varepsilon_0 = 8.85 \cdot 10^{-12}$ C²/(Nm²)
Threshold of hearing (human ear, 1kHz)	$J_0 = 10^{-12}$ W/m²
Image distance of the reduced eye	i=17 mm

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.630	33 **As** 74.922	34 **Se** 78.97	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.95	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (271)	107 **Bh** (270)	108 **Hs** (277)	109 **Mt** (276)	110 **Ds** (281)	111 **Rg** (280)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **Mc** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
# Actinide series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

DENSITY

elements	ρ (g/cm³)	composit materials	ρ (g/cm³)
aluminium (Al)	2.7	Body tissues (soft, mean)	1.04
copper (Cu)	8.96	blood (mean)	1.05
tin (Sn)	5.75	air (0°C, 101 kPa)	0.00129
iron (Fe)	7.9	bone (mean)	1.7
silver (Ag)	10.5	fat (mean)	0.92
mercury(Hg)	13.6	muscle (mean)	1.06
gold (Au)	19.3	water (4°C)	1.000
lead (Pb)	11.3	ice (0°C)	0.92
carbon (C, graphite)	2.23	ethanol	0.8
carbon (C, diamond)	3.51	zirconia (ZrO_2)	6.0
carbon (C, fullerene)	1.65	amalgam (mean)	12
titan (Ti)	4.51	quartz (SiO_2)	2.65
		PMMA (poly(methyl-methacrylate))	1.2

SURFACE TENSION

material	σ (mJ/m²)
water	73
mercury	486
ethanol	22

SPECIFIC HEAT

material	c (kJ/(kg·K))
wolfram (W) (Tungsten)	0.132
water	4.18
ice	2.094
ethanol	2.4
muscle	3.76
blood	3.9
bone (solid)	1.3
fat	3
Body tissues (mean)	3.5
oxygen (C_v)	0.65
oxygen (C_p)	0.92

LATENT HEAT

material	q (kJ/kg)
ice (melting)	334.4
water (evaporation (100°C, 101 kPa))	2257
water (evaporation (30°C, 101 kPa))	2400

SPECIFIC CONDUCTANCE

material	σ(S/m)
muscle	0.8

COEFFICIENTS OF LINEAR THERMAL EXPANSION

material	α (10^{-6} 1/K)
aluminium	24
steel	12
amalgam	25
ice	51
teflon	200

ABSOLUTE INDEX OF REFRACTION

material	n (589 nm, 20°C)
air	1
water	1.333
cedar oil	1.505
diamond	2.417
glass	1.5
flintglass	1.6
prism (in refractometer)	1.739

SPECIFIC ROTATION

material	$[\alpha]_D^{20} \left(\frac{{}^\circ \cdot cm^3}{g \cdot dm}\right)$
D-glucose (dextrose)	+52.7
D-saccharose (sucrose)	+66.5
D-galactose	+80.2
D-lactose	+55.3
D-fructose (levulose)	–93.8
D-maltose	+137.5

SPEED OF SOUND

material	c (m/s)
air	330
helium	970
water	1500
body tissue (soft)	1600
bone	3600

MASS ATTENUATION COEFFICIENT

material	μ_m (cm^2/g)
lead (24Na, γ radiation)	0.05

VISCOSITY

material	η (mPa•s)
water (20°C)	1
water(25°C)	0.85
blood (37°C, in aorta)	4.5
air	0.02
ether	0.23
mercury	1.55
glycerol	1500

TISSUE WEIGHTING FACTORS

material	w_T
bone marrow (red)	0.12
colon	0.12
lungs	0.12
stomach	0.12
breast	0.12
gonads	0.08
bladder	0.04
liver	0.04
oesophagus	0.04
thyroid	0.04
skin	0.01
bone surface	0.01
salivary glands	0.01
brain	0.01
remainder	0.12

RADIATION WEIGHTING FACTORS

Radiation and energy range	w_R
photon	1
electron	1
Neutron	5-20
Proton, E_p > 2 MeV	5
α particle, heavy nuclei	20

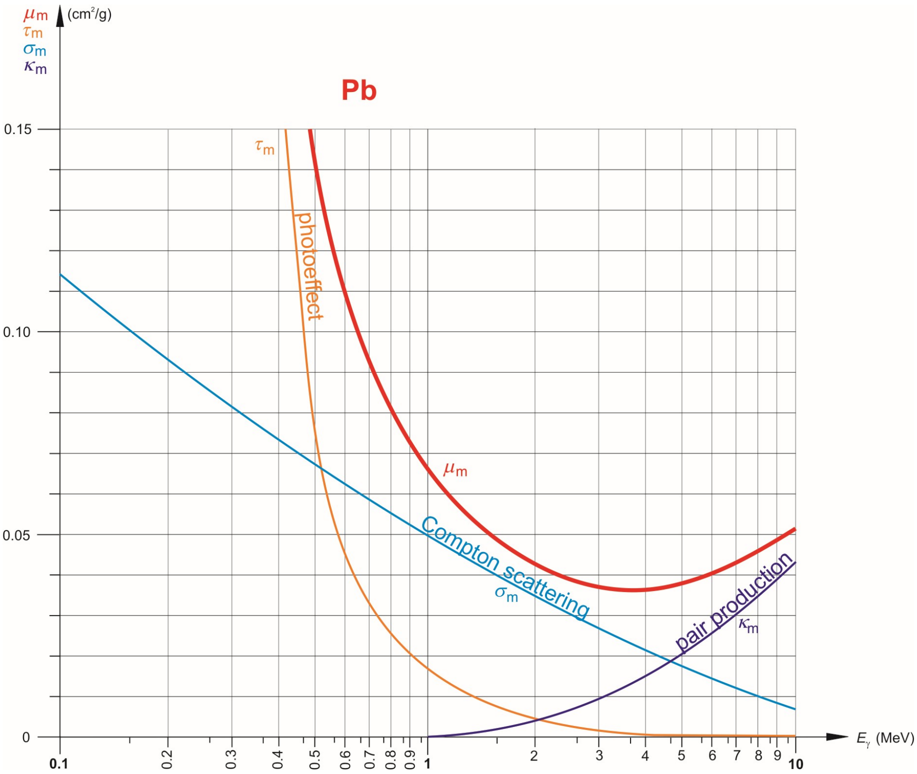
OSMOTIC COEFFICIENT

material	φ
NaCl	0.92
$CaCl_2$	0.85
glucose	1.00
KCl	0.92
Na-lactate	0.98

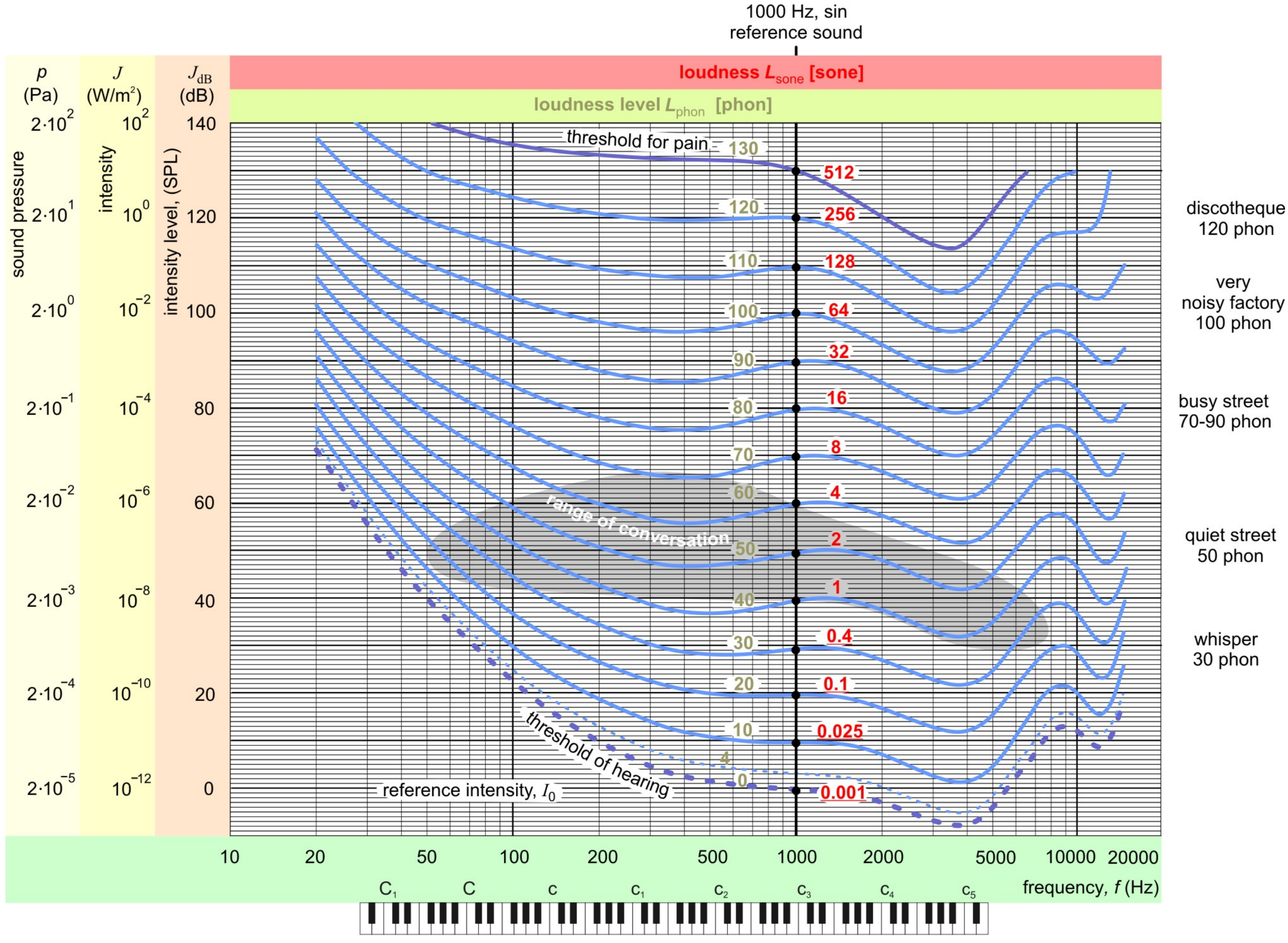
PROPERTIES OF SOME IMPORTANT RADIOISOTOPES

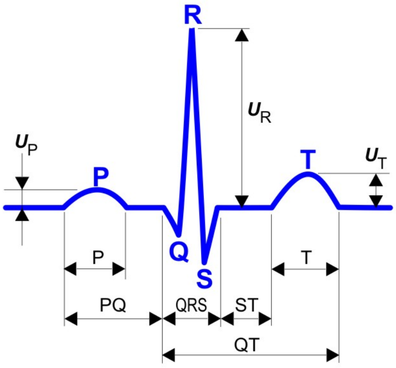
Chemical element and its atomic number		**Symbol of the isotope**	**Physical half-life**	**Type of decay**	**Maximum particle energy** (MeV)	γ**- energy** (MeV)	K_γ **dose constant** $\left(\frac{\mu Gy_{air} \cdot m^2}{GBq \cdot h}\right)$
Hydrogen	1	^{3}H	12.33 years	β^-	0.0186	–	
Carbon	6	^{11}C ^{14}C	20.4 minutes 5760 years	β^+ β^-	0.96 0.155	–	
Nitrogen	7	^{13}N	10 minutes	β^+	1.19	–	
Oxygen	8	^{15}O	2 minutes	β^+	1.73	–	
Fluorine	9	^{18}F	109.8 minutes	β^+	0.633	–	
Sodium	11	^{24}Na	15.02 hours	β^-, γ	1.392	2.754 1.369	444
Phosphorus	15	^{32}P	14.28 days	β^-	1.710	–	
Sulfur	16	^{35}S	87.2 days	β^-	0.167	–	
Potassium	19	^{40}K ^{42}K	$1.28 \cdot 10^9$ years 12.36 hours	β^-, K (10%) β^-, γ	1.31 3.52 (75%) 1.99 (25%)	1.46 after K 1.525	
Calcium	20	^{45}Ca	163 days	β^-	0.257	–	
Chromium	24	^{51}Cr	27.7 days	K, e^-, γ	0.315 (e^-)	0.320	
Iron	26	^{52}Fe ^{59}Fe	8.2 hours 44.6 days	β^+, γ β^-, γ	0.8 1.566	0.5 1.30 1.10	 160
Cobalt	27	^{60}Co	5.272 years	β^-, γ	0.318	1.33 1.17	305
Copper	29	^{64}Cu	12.74 hours	β^- (39%) β^+ (19%) K (42%) γ (1%)	0.575 0.656	 1.34	
Krypton	36	^{85}Kr	10.73 years	β^-, γ	0.687	0.514	
Rubidium	37	^{81}Rb ^{86}Rb	4.7 hours 18.65 days	β^+, γ β^-, γ	0.99 1.78	1.93 0.95 1.078	
Strontium	38	^{90}Sr	29 years	β^-	0.546	–	
Yttrium	39	^{90}Y	64 hours	β^-, γ (0,4%)	2.29	1.761	
Technetium	43	$^{99}Tc^{m}$	6.02 hours	γ	–	0.140	
Indium	49	$^{113}In^{m}$	1.658 hours	γ	–	0.391	
Iodine	53	^{123}I ^{125}I ^{131}I	13.3 hours 59.7 days 8.04 days	K, γ K, γ β^-, γ	– – 0.606 0.25 0.81	0.16 0.0355 0.364 0.080 0.723	 54
Xenon	54	^{133}Xe	5.29 days	β^-, γ	0.346	0.081	
Caesium	55	^{137}Cs	30.1 years	β^-, γ	0.512 (92.6%) 1.173 (7.4%)	0.661	80
Gold	79	^{198}Au	2.695 days	β^-, γ	0.961	0.411	
Mercury	80	^{203}Hg	46.6 days	β^-, γ	0.212	0.279	
Radon	86	^{222}Rn	3.824 days	α	5.489	–	
Radium	88	^{226}Ra	1600 years	α, γ (6%)	4.784 4.598	0.186 0.260 0.609	
Uranium	92	^{238}U	$4.47 \cdot 10^9$ years	α, γ	4.2	0.048	

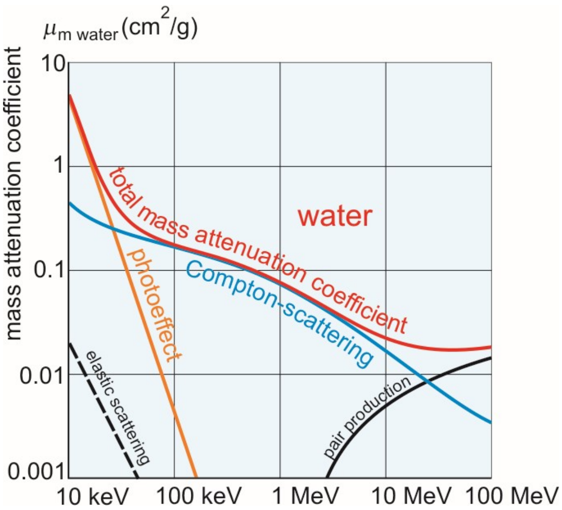
COMPONENTS OF THE MASS ATTENUATION COEFFICIENT OF LEAD

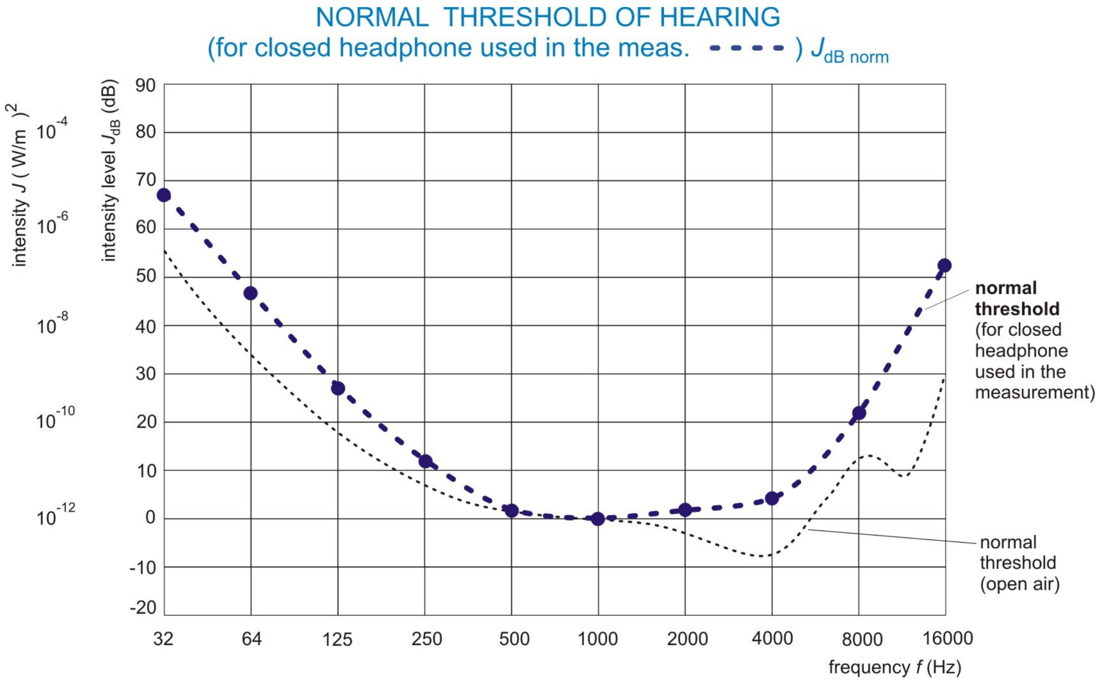


ISOPHON CURVES









I.	II.	III.	IV.	V.
chamber(s) paced	chamber(s) sensed	response to sensing	rate modulation	multisite pacing
0 = None	0 = None	0 = None	0 = None	0 = None
A = Atrium	A = Atrium	I = Inhibitory	R = Rate modulation	A = Atrium
V = Ventricle	V = Ventricle	T = Triggered		V = Ventricle
D = Dual (A+V)	D = Dual (A+V)	D = Dual (I+T)		D = Dual (A+V)

STATISTICS

$$\bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

$$\bar{x} = \frac{\sum_{i=1}^{n} n_i x_i}{n}$$

$$s_{x,n-1} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} = \sqrt{\frac{Q_{xx}}{n-1}}$$

$$s_{\bar{x}} = \frac{s_x}{\sqrt{n}}$$

$$z = \frac{x - \mu}{\sigma}$$

$$\bar{x} \pm t_{\%} s_{\bar{x}}$$

$$\bar{x} \pm t_{\%} s_x$$

$$t_{[n-1]} = \frac{\bar{x}}{s_{\bar{x}}}$$

$$t_{[n-1]} = \frac{\bar{x} - \mu_0}{s_{\bar{x}}}$$

$$t_{[n_1+n_2-2]} = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{Q_1 + Q_2}{n_1 + n_2 - 2}}}\sqrt{\frac{n_1 n_2}{n_1 + n_2}}$$

$$Q_1 = \sum_{i=1}^{n_1}(x_{1i} - \bar{x}_1)^2 \quad \text{és} \quad Q_2 = \sum_{i=1}^{n_2}(x_{2i} - \bar{x}_2)^2$$

$$F_{[n_1-1;n_2-1]} = \frac{s^2_{\text{larger}}}{s^2_{\text{smaller}}}$$

$$s_g^2 = \frac{\sum_{j=1}^{h} n_j\left(\bar{x}_j - \bar{\bar{x}}\right)^2}{h-1} = \frac{Q_g}{h-1}$$

$$s_i^2 = \frac{\sum_{j=1}^{h} Q_j}{N-h} = \frac{\sum_{j=1}^{h}\sum_{i=1}^{n_j}(x_{ij} - \bar{x}_j)^2}{N-h} = \frac{Q_i}{N-h}$$

$$t_{[n-1]} = \frac{\bar{R}}{\frac{s}{\sqrt{n}}}$$

$$Q(a,b) = \sum_{i=1}^{n}[y_i - (ax_i + b)]^2$$

$$a^* = \frac{Q_{xy}}{Q_{xx}} = \frac{s_{xy}^2}{s_x^2}$$

$$Q_{xy} = \sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})$$

$$Q_{xx} = \sum_{i=1}^{n}(x_i - \bar{x})^2$$

$$s_{xy}^2 = \frac{Q_{xy}}{n-1}$$

$$b^* = \bar{y} - a^*\bar{x}$$

$$r = \frac{Q_{xy}}{\sqrt{Q_{xx}Q_{yy}}} = \frac{s_{xy}^2}{s_x s_y}$$

$$t_{[n-2]} = r\sqrt{\frac{n-2}{1-r^2}}$$

$$\chi^2 = \sum_i \frac{(O_i - E_i)^2}{E_i}$$

$$\chi^2_{[1]} = \frac{n(ad - bc)^2}{(a+b)(c+d)(a+c)(b+d)}$$

$$\log(a \cdot b) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log a^b = b \cdot \log a$$

$$H = p\log_2\left(\frac{1}{p}\right)$$

$$I = \log_2\left(\frac{1}{p}\right)$$

$$p(A) = \frac{k}{n}$$

$$p(AorB) = p(A) + p(B) - p(AandB)$$

$$p(A \mid B) = \frac{p(AandB)}{p(B)}$$

$$odds = \frac{p}{1-p} = \frac{p}{q}$$

$$p = \frac{odds}{1+odds}$$

logit (A)=ln(odds(A))

logit(not A)=-logit(A)

odds(A)=e$^{\text{logit(A)}}$

$$odds(\text{not A}) = \frac{1}{odds(A)}$$

$$\text{RR} = \frac{p(B_+|R_+)}{p(B_+|R_-)} = \frac{\frac{a}{a+b}}{\frac{c}{c+d}} = \frac{a(c+d)}{c(a+b)}$$

$$\text{OR} = \frac{\frac{p(B_+|R_+)}{p(B_-\mid \text{R}_+)}}{\frac{p(B_+\mid R_-)}{p(B_-\mid R_-)}} = \frac{ad}{bc}$$

$$\mu = E(\xi) = \sum_i x_i p_i$$

$$\sigma^2 = D^2(\xi) = E[(\xi - E(\xi))^2] = \sum_i \left((x_i - \mu)^2 \cdot p(x_i)\right)$$

$$\eta = \xi + k \rightarrow E(\eta) = E(\xi) + k\,; Var(\eta) = Var(\xi)$$

$$\eta = \xi \cdot k \rightarrow E(\eta) = E(\xi) \cdot k\,; Var(\eta) = Var(\xi) \cdot k^2$$

$$\eta = \xi_{norm} \cdot \omega_{norm} \rightarrow E(\eta) = E(\xi) \cdot E(\omega)$$

$$\eta = \xi + \omega; E(\eta) = E(\xi) + E(\omega)\,; Var(\eta) = Var(\xi) + Var(\omega)$$

if independent

$$\eta_{E=0;Var=1} = (\xi - E(\xi)) * \frac{1}{\sqrt{Var(\xi)}} = \frac{(\xi - E(\xi))}{\sqrt{Var(\xi)}}$$

$$p(x_i) = \frac{1}{n} \quad \mu = \frac{n+1}{2} \quad \sigma^2 = \frac{n^2-1}{12}$$

$$f(x) = \begin{cases} \frac{1}{b-a}, & \text{if } a \le x \le b \\ 0, & \text{otherwise} \end{cases}$$

$$\mu = \frac{a+b}{2} \quad \sigma^2 = \frac{(b-a)^2}{12}$$

$$p_k = \binom{n}{k} p^k (1-p)^{n-k}$$

$$\mu = np \qquad \sigma^2 = np(1-p)$$

$$p_k = \frac{\lambda^k}{k!} e^{-\lambda} \qquad \mu = \lambda \qquad \sigma^2 = \lambda$$

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} = N(\mu, \sigma)$$

$$\sum \frac{(x_i)^k}{n}$$

$$\sum \frac{(x_i - \mu)^k}{n}$$

$$w = \frac{diseased}{total} = \frac{FN+TP}{TN+FP+FN+TP}$$

$$se = \frac{TP}{diseased} = \frac{TP}{FN+TP}$$

$$sp = \frac{TN}{healthy} = \frac{TN}{TN+FP}$$

$$1 - se = \frac{FN}{diseased} = \frac{FN}{FN+TP}$$

$$1 - sp = \frac{FP}{healthy} = \frac{FP}{TN+FP}$$

$$PPV = \frac{TP}{positive} = \frac{TP}{FP+TP}$$

$$NPV = \frac{TN}{negative} = \frac{TN}{FN+TN}$$

$$1 - PPV = \frac{FP}{positive} = \frac{FP}{FP+TP}$$

$$1 - NPV = \frac{FN}{negative} = \frac{FN}{FN+TN}$$

$$de = \frac{TP+TN}{total} = \frac{TP+TN}{TP+FN+TN+FP}$$

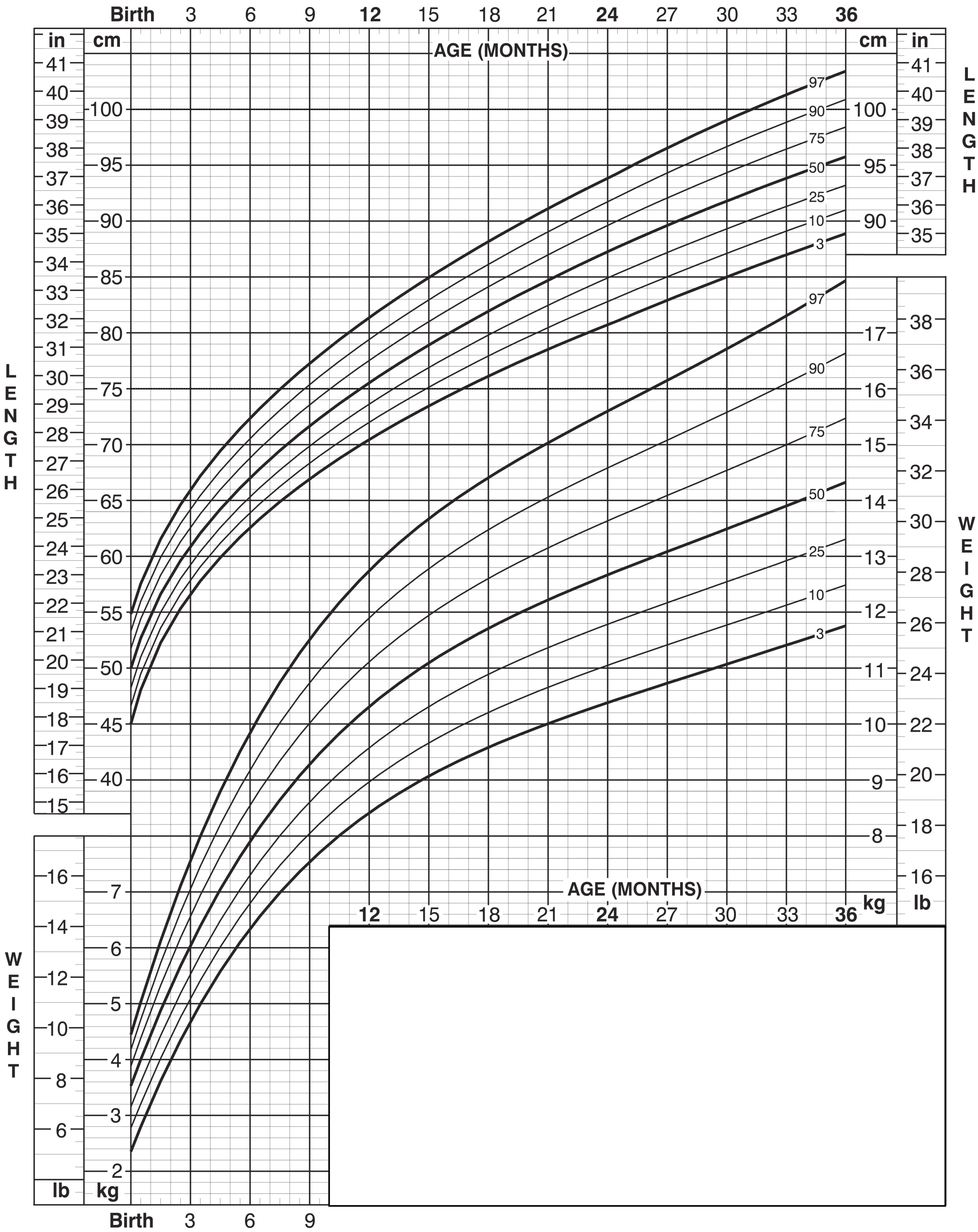
T-DISTRIBUTION

degree of freedom	*p* (probability, two-tailed)							
	0.5	0.2	0.1	0.05	0.02	0.01	0.002	0.001
1	1.00	3.08	6.31	12.7	31.8	63.7	318.3	636.6
2	0.82	1.89	2.92	4.30	6.96	9.92	22.3	31.6
3	0.76	1.64	2.35	3.18	4.54	5.84	10.2	12.9
4	0.74	1.53	2.13	2.78	3.75	4.60	7.17	8.61
5	0.73	1.48	2.02	2.57	3.37	4.03	5.89	6.87
6	0.72	1.44	1.94	2.45	3.14	3.71	5.21	5.96
7	0.71	1.41	1.89	2.36	3.00	3.50	4.79	5.41
8	0.71	1.40	1.86	2.31	2.90	3.36	4.50	5.04
9	0.70	1.38	1.83	2.26	2.82	3.25	4.30	4.78
10	0.70	1.37	1.81	2.23	2.76	3.17	4.14	4.59
11	0.70	1.36	1.80	2.20	2.72	3.11	4.02	4.44
12	0.70	1.36	1.78	2.18	2.68	3.05	3.93	4.32
13	0.69	1.35	1.77	2.16	2.65	3.01	3.85	4.22
14	0.69	1.35	1.76	2.14	2.62	2.98	3.79	4.14
15	0.69	1.34	1.75	2.13	2.60	2.95	3.73	4.07
16	0.69	1.34	1.75	2.12	2.58	2.92	3.69	4.01
17	0.69	1.33	1.74	2.11	2.57	2.90	3.65	3.97
18	0.69	1.33	1.73	2.10	2.55	2.88	3.61	3.92
19	0.69	1.33	1.73	2.09	2.54	2.86	3.58	3.88
20	0.69	1.33	1.72	2.09	2.53	2.85	3.55	3.85
21	0.69	1.32	1.72	2.08	2.52	2.83	3.53	3.82
22	0.69	1.32	1.72	2.07	2.51	2.82	3.51	3.79
23	0.69	1.32	1.71	2.07	2.50	2.81	3.49	3.77
24	0.68	1.32	1.71	2.06	2.49	2.80	3.47	3.75
25	0.68	1.32	1.71	2.06	2.49	2.79	3.45	3.73
30	0.68	1.31	1.70	2.04	2.46	2.75	3.39	3.65
40	0.68	1.30	1.68	2.02	2.42	2.70	3.31	3.55
60	0.68	1.30	1.67	2.00	2.39	2.66	3.23	3.46
120	0.68	1.30	1.66	1.98	2.36	2.62	3.16	3.37
∞	0.68	1.29	1.64	1.96	2.33	2.58	3.09	3.29

χ^2 (CHI-SQUARE)-DISTRIBUTION

degree of freedom	*p* (probability, right)						
	0.99	0.975	0.95	0.05	0.025	0.01	0.001
1	0.0000157	0.0000982	0.000393	3.84	5.02	6.63	10.83

LEGTH- AND WEIGHT-FOR-AGE PERCENTILES; BOYS



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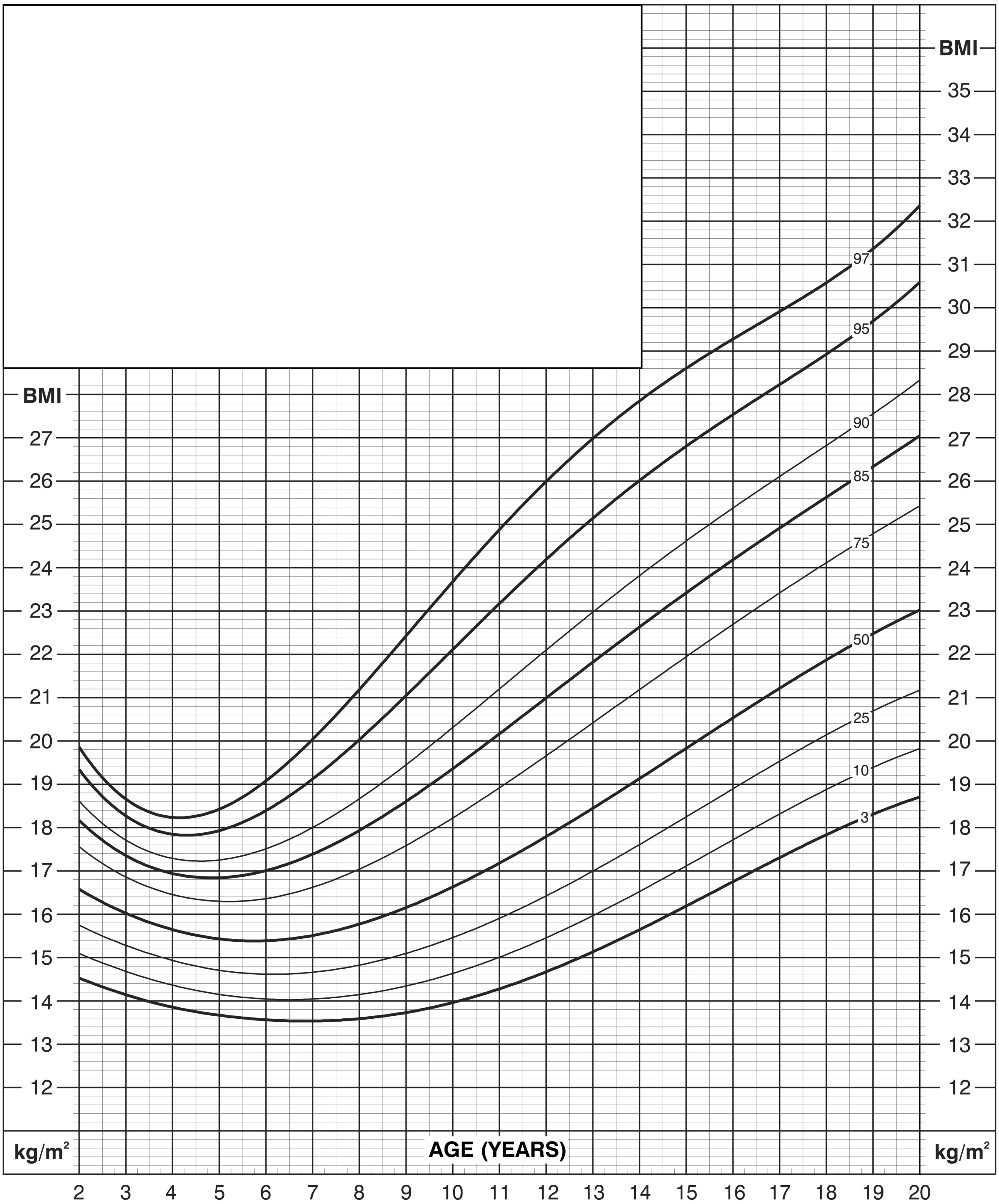

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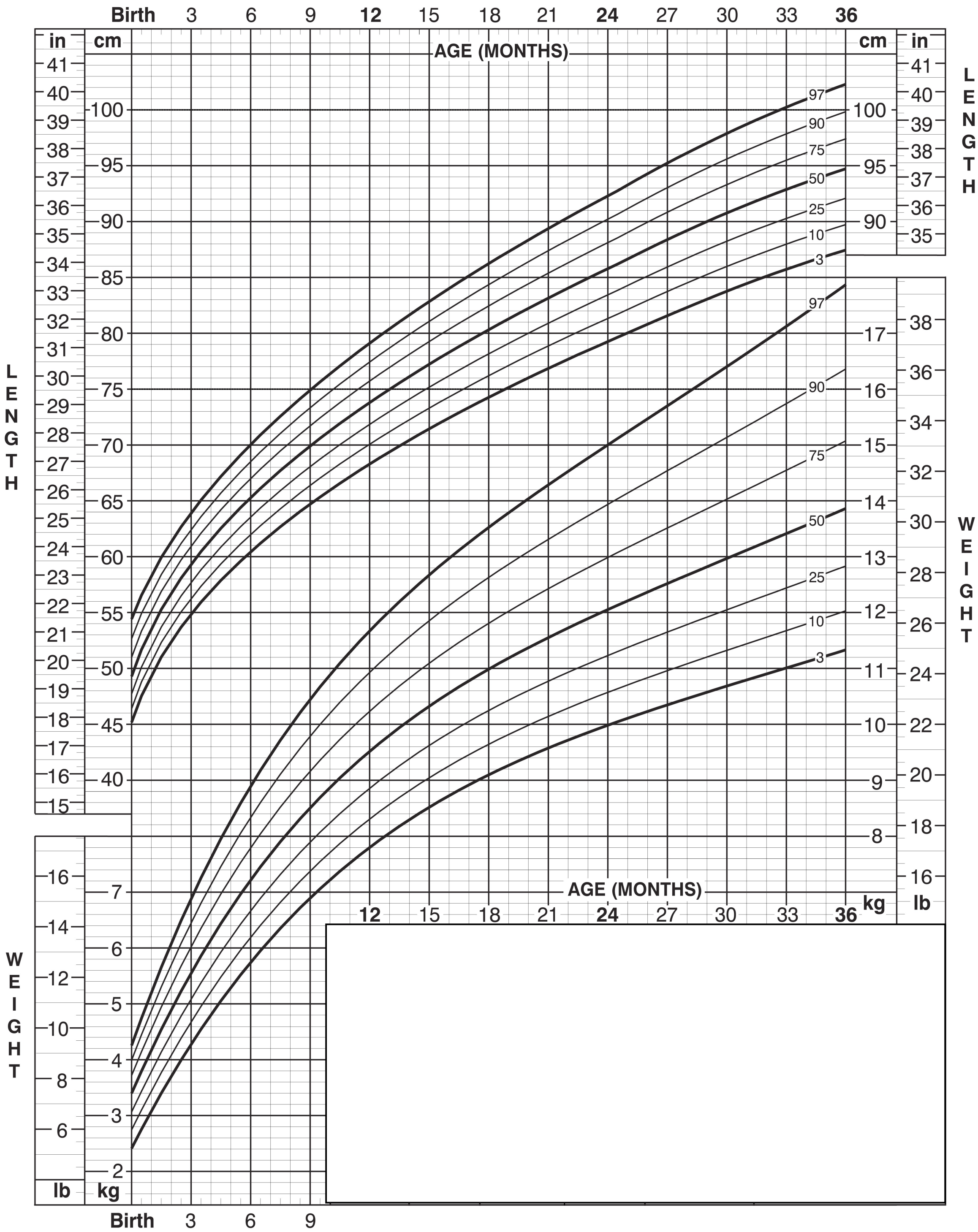

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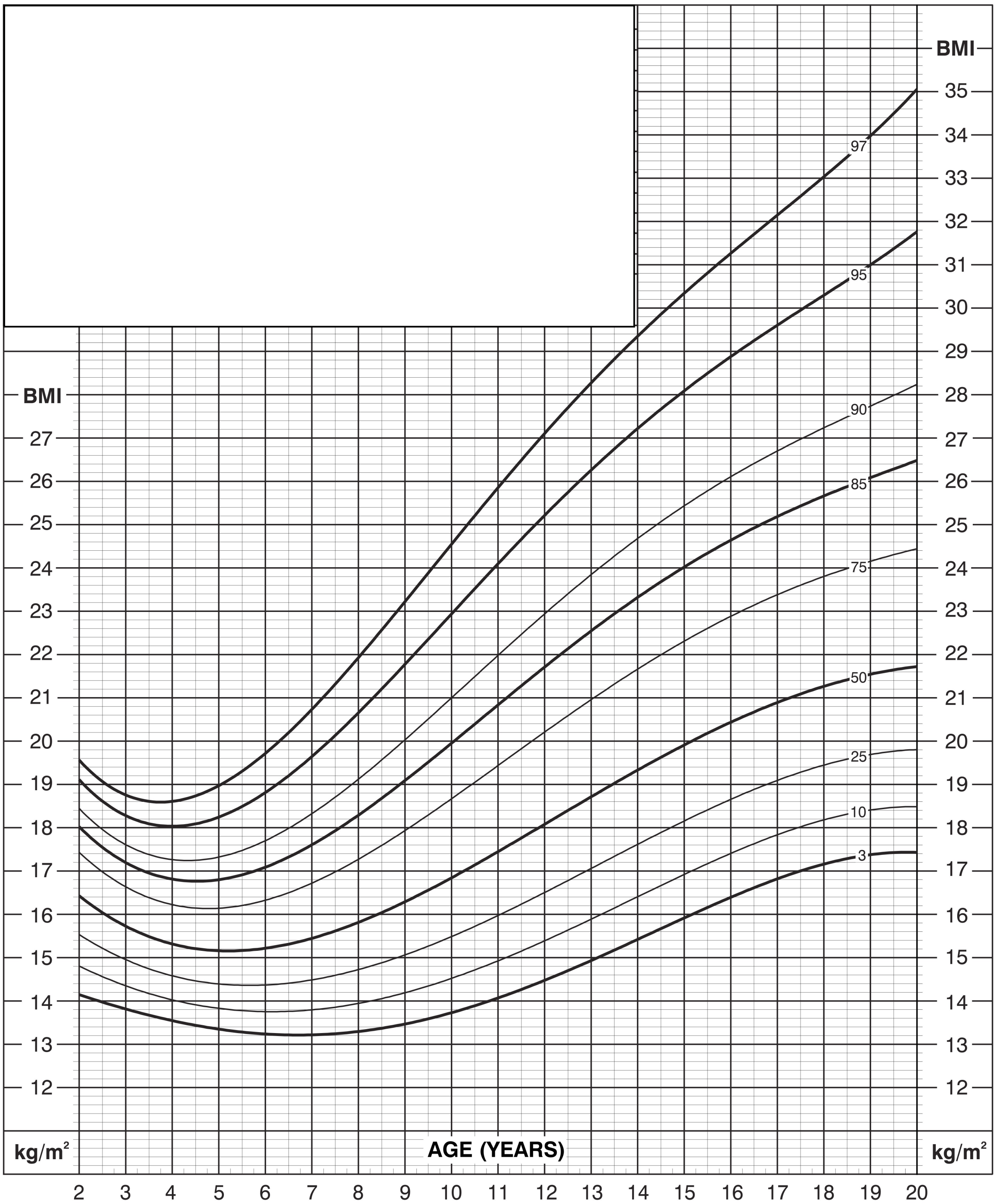

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