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Anthromathematics: a New Branch of Mathematics

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This lecture introduced activities of the Mathematical Biology Group, with a brief introduction to mathematical models of brain (covariant, generalized coupling, covariant generalized coupling, mathematical definition of brain death), heart (standing wave), spinal column (static and dynamic) and physical growth of children (ICP, KFA, KJK; last two developed during the course of the NGDS Pilot Project). *Anthromathematics* was defined as the mathematics of human body sizes, forms, proportions and structures. The term was first used on March 22, 2010 by the author during the First Conference on Mathematical Sciences held at University of Karachi. Third millennium challenges required that the sciences of *anthropology* (study of human being) and *anthropometry* (measurement of human being) be transformed to *anthromathematics* through ideas from mathematics, *e. g.*, mathematical equations employed to approximate human body form (*analysis* — formulae for surface area and volume of human body), discrete structures recognized in the anatomy and the physiology of human body (*algebra* — brain death defined, mathematically, through study of group structure), invariance under deformations discovered (*topology* — spinal column deformed because of scoliosis, kyphosis or lordosis, studied by static and dynamic models), properties of numbers studied (*number theory* — numbers giving height, weight and other anthropometric measures) as well as inferences analyzed (*logic* — upper limits of optimal weight-for-height). To elaborate the point further, an *anthropometrist* is supposed to take heights, but an *anthromathematician*, not only, must measure heights, but also, determine accuracy, precision and reproducibility of the techniques used, while planning the session, align the scale, ascertain that the surface is level, check the equipment against agreed-upon standards at the start of each session and, finally, estimate consistency of collected data at the end of every session. Measurement of height was used to teach the mathematical concepts of serial measurements, graph plotting, slope computation, height function as time series, estimation of adult height and comparison with cut-off height for armed-forces careers. A situation, in which engineering tape was mounted in a tilted position by mistake, was used to teach the following concepts: (*a*) Computation of hypotenuse from perpendicular (trigonometry); (*b*) A line parallel to base intersects the sides of triangle such that the line segments are proportional (geometry). Similarly, measurement of weight offered opportunities to teach concepts in mathematics (estimated-adult weight, nude-weight computation from clothed weight, optimal weight-for-height). The focus, then, shifted towards mathematical model of physical examination. Mathematical concepts used in the physical examination were elaborated: (*i*) *symmetry* (left-right) in the body shape, size, number of limbs (fingers, toes), anatomical landmarks (scapulae, body triangles, spinal dimples, shoulder/neck line, knee joints, in the context of scoliosis indicators) — asymmetry as the first indicator of breast cancer, (*ii*) *inverse problem* — determining properties of source from the properties of field (*e. g.*, auscultation using stethoscope; the sound recorded from heart, lungs or stomach comes through the body tissue and skin, which must be accounted for), radiative-transfer equation was used to compute intensity, when source function was known (proper interpretation of X-ray intensity in CT scan using radiative transfer equation brought Nobel Prize in medicine, basis of clinical thermograms), (*iii*) *precedence graph* — some checks have to be performed before the others, overlooking this might effect, adversely, on patient's health (*e. g.*, examination of resting heart to be performed before treadmill testing, or hernia check must precede cardiac function testing in the squatting position), (*iv*) *influence graph* — some procedures influence certain portions of the examination (*e. g.*, running influenced blood pressure and heart rate). There is, therefore, a need a devise protocols of examination in such a way that interacting procedures are performed in a laid-down sequence, or during separate sessions. These protocols must indicate which procedures must precede the others and which ones could be performed concurrently (*e. g.*, cardiac function in the standing position and check for undescended testicles). The techniques used in physical examination by a medical professional consist of auscultation, percussion and olfaction (all three employ *inverse problem*), inspection (employs symmetry) and palpation (employs properties of material, body temperature). Facilities available in SF Growth and Imaging Laboratory operated by Mathematical Biology Group, University of Karachi include stereophotogrammtery (moiré fringe topography, rasterstereography), video analysis, height and weight measurements to accuracies of 0.01 *cm* and 0.01 *kg*, respectively as well as software to generate growth-and-obesity profiles of children.

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