Teaching Biology in a Human Context

by

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"Your body is a space capsule, your head the command module." So begins the introduction to a three-dimensional moving pop-up picture book on the human body now available in the U.K. "When you reach puberty your hormones switch on," announces a heading in the London Science Museum permanent exhibition called *A Study of Ourselves*. An advertisement for beer displayed on vast billboards in the U.K. recently shows a series of ape-like figures progressively reaching a vertical posture, the penultimate figure with a bowler hat (symbol of the English business gentleman) and the final figure carrying a can of the appropriate beer. A question mark points to the potential evolutionary leap which awaits discerning drinkers.

These three examples are particularly gross reflections of deeply held beliefs in the West, beliefs firmly underpinned by faith in scientific objectivity. One of these is that the human body is nothing more than a highly complex machine which human beings will eventually be able to take apart and reconstruct. A second, that our bodies and our minds are subject to the outcome of a complex chemistry. The third, that human beings have evolved from a primitive animal condition and that any further evolution is in the random and arbitrary hands of environmental influences. In teaching any science to adolescents one is aware of the forceful nature of these beliefs which are carried subliminally or openly throughout our culture.

One of the hallmarks of a good scientific theory is that it should be capable of being disproved. This would seem to guarantee the absence of dogma in science, as any theory worth its salt will, by definition, eventually be superseded. Human nature, however, is stronger than scientific principle, so from black holes in space to human evolution, theories rapidly harden into tablets of stone brought down from a mountain of research. If we experience surprise, displeasure or vague discomfort in reading such statements as those below, then we can be sure that we are taking current theories for granted or carrying memories of school science unchallenged within us:

- atoms do not exist,
- human beings did not evolve from apelike ancestors,
- life did not arise from a primeval organic soup, nor the universe in a gigantic explosion,
- the sun is not a ball of atomic fire,
- the heart is not a kind of pump,
- the brain is not a kind of computer.

Any twinges? How free are we to consider alternative views or even challenge current ones in our thinking? Cemented and consolidated over years of experimental measurement, poured out in textbooks, magazines, films, games and models, opposition can invite ridicule, disbelief or the accusation of a lack of objectivity or ignorance of highly specialist research techniques. Yet the history of science is filled with the birth of ideas that ran directly counter to customary modes of thinking, and the very birth of scientific enquiry was the birth of an independent and free spirit of inquiry, unconstrained by tradition and religious or social pressures and prejudices. The biographies of Galileo and Darwin illustrate the struggles.

What is objectivity? Is it confined to what can be measured in mass, distance and time, or can it include the faculty of observation, thinking and an open mind? There may be few technological or military applications in an open-minded contemplation of the universe, but this must surely always remain the bedrock of free-thinking inquiry and scientific progress. We stifle or undermine it at our peril.

These considerations are crucial to the teaching of science to adolescents in a Waldorf school, and the main lesson periods in Human Science for Grades 9 and 10 (fourteen- to sixteen-year-olds) illustrate this. The periods are most commonly known as Human Science to allow the widest possible context to the biology arising from this. How can the wealth of knowledge currently available about the human body, for example, be presented without a fragmentary succession of organs and systems, implying that all these and more constitute the whole? What meaning does the liver have torn from its context of blood and digestion? What meaning does the digestive system have, torn from the context of daily life? What meaning do any of these organs have in relation to my inner experience as a human being? A teacher could be tempted to overcome these problems and make the subject relevant to life merely by linking the study of items of popular interest; alcoholism, liver disease, digestion and a healthy diet. Such connections stimulate interest but alone they fail to meet the adolescent's deeply held conviction that there is meaning and mystery in the world. Unless there is a context for biology which carries "food" for these, an adolescent's thinking will be confined by the practical or the popular, and deeper, less conscious questions will remain unaddressed.

One aspect of biology that has, until recently, received little consideration is that of form— why living things have the shapes they do. In human science a considerable part of the work should be an experience of form by drawing and modeling, so that observation and thinking retain all the mobility which other lessons like those in music, art and movement have developed.

To illustrate how observation and thinking can create a meaningful context within which fine details and invisible processes can be studied, take the form of the human skeleton. The form of the human head is spherical. At the extremities of the body are opposite forms, linear, angular, jointed. Between head and legs, the ribs (which are both linear and curved) create a materially incomplete enclosed surface (the rib-cage), protecting the soft tissues of heart and lung as the skull does brain and the bone, marrow. The head is still, the skull plates fused, with only the jaw bone moving, like a limb. The upper ribs move in breathing but are fused together by the sternum. The lower ribs are freer hanging, limb-like, opening up the chest cavity into the abdomen. Following these forms and their movements, the opposite qualities of skull and limb with the balancing features of the ribs are clear to see. Care in observation and a thinking faculty which can rove over the contrasts as well as remember details and named parts build a meaningful whole, not quantifiable yet not arbitrary or fanciful. Such a picture can be followed into the forms of individual bones (the 'head' of the femur, for example) before it fades into the detail of bony tissue and the process of ossification. This type of approach can be extended to other parts of the body as well as the systems of organs commonly considered in a quite different context in any standard textbook or encyclopedia. The fundamental difference is that relationships between organs and systems can be considered and grasped without recourse to theories about neural/electrical transmission, nerve/muscle reflexes or sensory/motor nerves. Such considerations should follow as elaborations of thought, not be considered the foundation for understanding the whole organism.

The nervous system is centered in the head with nerves leading to and from all parts of the body. The brain rests, partly floating free of gravitational pressure in the cerebrospinal fluid. There is no movement, impulses are silent, invisible—we feel most awake here, alert, our senses concentrated here. Below the diaphragm, a sheet of muscle which divides the trunk, the digestive system begins metabolic processes whose outcome supplies the energy needs of muscles which meet the demands of gravity in the limbs. Movement, warmth and activity prevail here, and as a complement to the senses which receive impressions from the environment, limbs reach out and impress themselves upon it. Between the two extremes of shape and activity of head and limbs (nervous system and metabolic system) are the rhythmic movements of heart and lung. Rhythm is movement and stillness in harmony. Breathing leads substance outwards into the world and receives from it. The circulation of blood gives and receives inwardly.

Our experience of feeling is centered here, brought to consciousness by the head or expressed in movement through the limbs. Our inner experiences as human beings have their reflection in the form and activity of the bodily organs.

This brief and sketchy attempt to show the context within which the details of the human body may be taught to adolescents seeks to illustrate how a sense of wholeness and meaning can be the foundation of such a study. These pictures are neither fanciful nor arbitrary and are available to any keen observer with the controlled imagination which lies at the heart of objective knowledge about the world. They lead the adolescent to respect and have confidence in his own unaided faculties, so that further study of details and reading about experiments which explore the most minute aspects of physiology can be related to a meaningful whole. Another message received is that knowledge about the human body does not rest solely on the biochemical or genetic analyses of experts, but is a mystery open to any keen observer with clear and mobile thinking. Adolescents also have a context within which to appreciate and admire the results of medical technology alongside the deeper issues raised that challenge human attitudes to birth and death. The adolescent's burgeoning inner life is also confirmed as a reality which the body supports and responds: I have a brain but I am not my brain. I have feelings but I am not my feelings, I have a body but I am not my body.

Another outcome which follows a consideration of form in the human body is a consideration of the balance and harmony in its architecture. Observation of the animal world can show very clearly that by a one-sided emphasis of the peripheral parts of the human skeleton, for example, specialized animal limbs arise. For example, an extreme development of the digits of the hand gives rise to a bat's wing, bone for bone. One-sided development of the forefinger alone creates the horse's hoof, while any distortion of the balanced forms of human teeth quickly creates herbivore (cow), carnivore (cat), or rodent (rat). Distortions of the human form always give rise to animal-like caricatures as the political cartoonist knows well. Such considerations leave open the question of how the human form evolved. Studies of the animal world return again and again to the human being without whom, after all, observations and questions would not exist.

In contrast to this emphasis on form comes what is usually considered the "real" content of biology: details of gaseous exchange in the lungs, respiration in the tissues, hemoglobin in the blood, excretion in the kidneys, enzyme activity in the alimentary tract. These substances and processes are not directly visible, and most of what is known about them is the outcome of detailed experimental investigations. They demand clear thinking and are vital exercise for the growing teenage intellect quite apart from the factual knowledge of their content. In differing degrees, with examples to stretch the ablest pupils, a whole class should experience the real satisfaction in understanding such biological processes and how each is coordinated with another, to create a harmonious balance against a changing environment. The context outlined previously makes it harder to fall into the satisfaction of the clever intellect which would anticipate that if only enough details were known and added together, like a gigantic biochemical construction kit, the whole organism would be explained.

As with all Waldorf teaching, the choice of what to study is so vast, that the question immediately facing a teacher is where to start. And so the choice is best determined through consideration of the developmental age of the class—also a Waldorf principle. In Class 9, thinking powers are usually not so fully developed as they will be in Class 10, and adolescents live very sharply in their senses, so a beginning can be made successfully with a study of the skin and the very visible and obvious sense organs, for example the eye. Its intricacy and sensitivity awakens and challenges any tendency to superficial comparisons with a camera. Analogies usually have very limited value and, when held to as teaching aids, seriously distort accurate observation, memory and thinking, leading quickly to the false sense that the eye has been explained. Details challenge such easy paths to understanding as these considerations may illustrate.

The light-sensitive cells in the retina actually point away from the light. The act of seeing involves the whole organism, not just the eye, and the image which reaches the retina bears little resemblance to our perceptions of the world around us. We cannot see light but only the outcome of its penetration of matter. At night, outer space is filled with light from the sun but appears black until reflected by the moon. So what is it that we "see"? Is it a coincidence that we say "I see" when we understand something? Dim stars cannot be seen looked at directly but appear when the focus of our gaze is turned slightly to one side. Is this not often true when we search our memories and thoughts? Suddenly a thought "dawns on us" and we see it "in a flash." The genius of language leads us to the widest considerations.

So, the opportunity arises to consider such fundamental questions as the nature of light or the biographies of individuals who have been deprived of sight or hearing. The widest possible considerations should be able to arise within a human science period.

In Class 10, the main lesson includes embryology and, as far as time allows, such themes as child development, racial or cultural differences, temperaments and personality. At this age a pupil's thinking ability and maturity are usually much more capable of doing justice to such topics, particularly to the development of the organs and the human questions that arise over abortion and embryo technology. The major organs of the body having already been considered, their development from layers of folding and enfolding tissue within a matrix of sustaining membranes is a rich and rewarding study. I have felt very privileged to experience how boys and girls of this age can be together and feel free to share some of their deepest concerns and feelings on life, death and relationships arising from an objective study of this miraculous process of development.

At an age when sexual physiology and the "facts of life," as they are so inaptly called, are outwardly known and serious relationships have often already begun, this study of embryology can come as a healing force to adolescents in their struggles to cope with the freedoms and the responsibilities our society has placed on them. It can be a fitting end to such a period to also include the question of old age. While we talk easily of growing up, it can be quite a revelation to adolescents that to become an adult is to embark on a lifelong experience of learning and development. The "seven ages of man" need not be limited to a decline from youthful vigor to dull senility but may include the pathway to self-knowledge and wisdom. Herein lies an opportunity for adolescents to perceive that the excitement and the challenge, as well as the doubts and anxieties they are struggling with within, are shared by parents and grandparents, too.

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