The Design of Human and Animal Bodies

Exercises from a Ninth Grade Biology Main Lesson
excerpt from a Workbook in preparation for publication
by Peter DeBoer,
Sacramento Waldorf High School

Pedagogical Themes

The ninth grader (age 14-15) is generally experiencing some part of the developmental stage known as puberty, in which the limb region of the body and associated processes reach a "near" maturity. In this way, the body may be described as "earth-ripe[1]" . This physical development coincides with the continued maturation of cognition, especially in the formation of abstract thoughts. Abstract thought is by its nature capable of being formed separately from the immediate life of sensation. At times this may become unrealistic or "fantastic" thought, and may lead to very aberrant behavior. Just as work gives the physical body something lawful and constructive to do with its energy, encouraging thinking to be anchored or checked by the apparently lawful qualities of nature accessed through careful observation provides a constructive outlet for abundant forces in the thinking life.[2]

The Anatomy block, from which this example is drawn, endeavors to use observation, a manifest capacity of will in the activity of thinking, to balance the growing capacity to form abstract thoughts. This balancing or rhythmical approach can build a healthy practice of thought. It is a healthy practice of thought that can help overcome the tendency to live habitually in fantasy and can lay the foundation for more complex thought necessary for morality, individual responsibility and free choice later in life.

The skill of pattern recognition is an important element in balancing perceptual and conceptual aspects of the developing human thinking. The more complex a pattern, the more complex the thinking must be, to understand or comprehend its different levels of meaning. While patterns can get very complex, the capacity of pattern recognition must start simply just like any living entity or process.

Pattern recognition can be encouraged through a number of in-class activities centered around observation. If observation activities are well-structured, they can serve as the foundation for an inquiry based approach to interesting puzzles and pattern anomalies. An example of a observation-based activity are "Observe and Describe Exercises."

Observe and Describe Exercises

These are short classroom inquiries which help provide the necessary structure for a novice observer, as opposed to the vague "please take a look at ..." approach. Each exercise includes an observation phase (perhaps a shorter focused "looking" period or a longer "looking and illustrating" period), a description phase, and a set of clear instructions such as: "Please take out a pencil and piece of paper, observe 'said' specimen or 2-3 minutes and describe at least five observations about ... (some aspect of "said" specimen).

[1] "Earth Ripeness": a specialized term coined by Rudolf Steiner (Ref. 1); also discussed by Michael Martin (Ref. 2) and in David Mitchell (Ref.3).

[2] "Logical thinking anchored in observation" first stage in development of thinking, discussed in Holdredge (Ref. 4).

Example Lesson Material:

A Descriptive Study of the Human Limb Bones

The human skeleton becomes the focus during the second week of my three week 9th grade Anatomy Main Lesson block. After reviewing and continuing the study of the skull started in grade 8, the students embark on a study of the human limb bones. The limbs are an anatomical region, the skeletal portion of which is also known as the Appendicular skeleton. The skull and limbs, both as regions and bony structures, are in direct contrast with one another–a clear example of polarity in living forms. The skull with its plate-like bones, still posture, and spherical shape is a clear polarity to the limb bones with their tubular bones, active mobility, articular orientation, and raying shape (see figure 1). To introduce studies of the limb, students are asked to explore the regular sequences of formation in this region and describe a general "limb pattern."

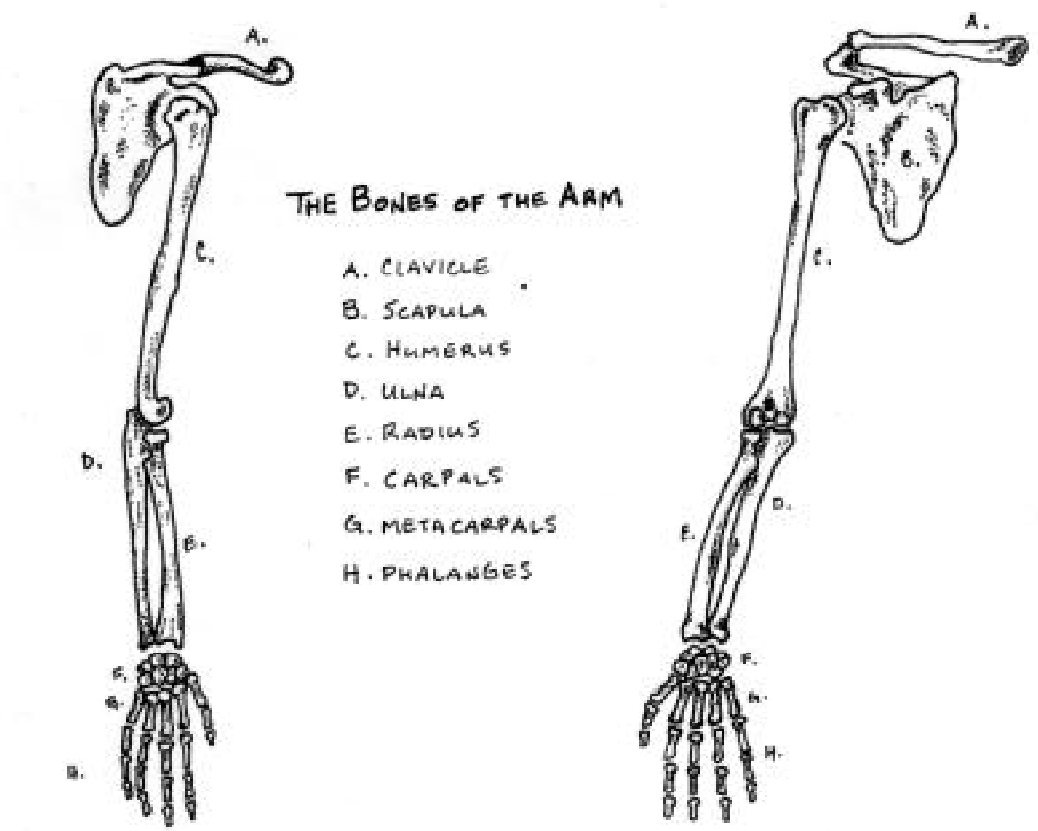

Figure 1 *Appendicular skeleton: arms*

Observe and Describe Exercise:

"Observe the bones of the limb, either arm or leg that are provided, and describe at least four characteristics of the osteological form. If you were creating a description of a general limb starting at one end or another, what characteristics would you include?" Using specimens and their own bodies, the students take about 10-15 minutes. and generally come up with some version of the following themes, which are then shared in discussion to assure that each student has a complete sequence (the following is oriented from proximal to distal):

i. *Point of Attachment*: the shoulder girdle (scapula and clavicle) in the arms or the pelvic girdle (coxal or innominate bones) in the legs, both with multiple, flat or plate-like, sometimes fused bones

ii. *A Ball and Socket Joint*:

iii. *Linear shaped, single, long bone* (i.e.: humerus or femur)

iv. *Continued series of joints* (generally hinge) *alternating with continued series of bones (*generally long bones*) of increasing numbers* (most evident in the fingers) .

v. *Overall prevalence of linear, tubular bones and joints for movement*

· This descriptive list becomes the *limb pattern,* and is used by the students as a starting point from which to make comparative inquiries. The first of these further studies is the investigation of how the bony structure at the point of attachment, or location on the trunk where the limb is joined to the whole body, differs from the overall pattern of the limbs. To do this the class is led by the teacher through a closer look at the three regions of the leg: the pelvis, the thigh and lower leg, and the foot (see Figure 2).

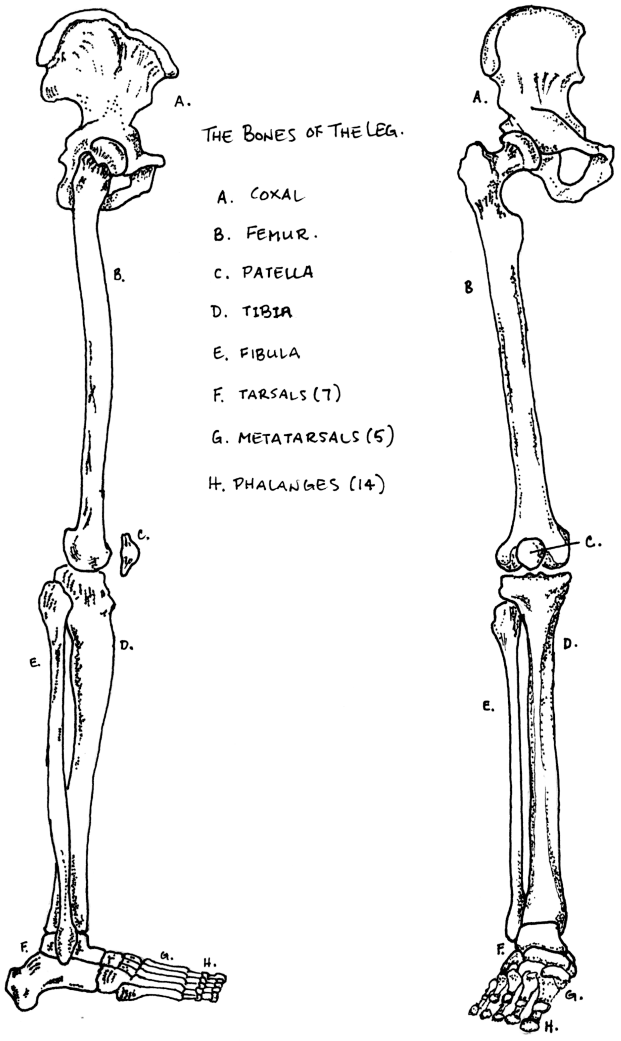

Figure 2: Appendicular Skeleton, Legs

i. The leg's point of attachment is named the pelvic region and is composed of the two "coxal" bones (hip joint). Each coxal is composed of three fused, mainly plate-like bones: the Illium (superior process), the Ishium (posterior process), and Pubic (anterior process).

ii. For efficienty of time, we then discuss together the question: "how do the coxals compare with the long bones?" [alternatively, this could be done as another observe-and-describe exercise]

Some findings the class comes to include:

a. The coxals are plate-like, rounded (while not quite spherical), and joined with sutures or fiberous joints.

b. In comparison the limb bones are of the tubular or linear type and possess moveable or synovial joints.

c. The students realize quickly how this pattern is similar to observations made about the skull (with its cranial and mandibular polarity)

To further develop these observations the students are then asked to describe (using the terms of position and direction: superior and inferior) where the plate like and tubular bones are located within the different regions of the human body. To aid in structuring this the students are asked to complete a data table including: the region's name, position of plate-like bones, continuation of the pattern, and any pattern anomalies (see TABLE 1 for a completed example).

Table 1.
Appendicular Skeleton, Arms and Legs

Region	Plate-like bones	Do they continue?	Anomalies
leg	coxal (superior) that are fused	no—linear long bones take over and movement becomes more evident	Patella
arm	scapula (superior) but clavicle is not plate-like	no—linear long bones take over and movement becomes more evident	clavicle & lack of fused plate bones
head (skull)	cranium (8 bones) many facial bones	yes (generally) and movement is not evident; only a single exception	mandible and facial bones

As these patterns are "fleshed out" and given context, the students become interested in the anomalies within each area. Usually this initially emerges as questions of whether these invalidate the pattern. However, having developed an understanding of the polarity of cranium and mandible within the skull region, the students are now experienced enough to explore an anomaly, such as the clavicle (see figure 1 above, again), with their observation rather than speculation and abstraction. Optionally, the patella and facial bones could be explored as anomalies with their appropriate anatomical region in the same manner as the clavicle exploration below.

Observe and Describe Exercise ("Exploring the anomaly of the clavicle")

"Observe the point of attachment in both the arm and the leg, and describe in one sentence each, how the arms and legs move differently at these locations." The students are reminded of their understanding of joint types, particularly the ball and socket joint, at which a limb has three directions of movement: anterior/posterior, medial/lateral, and clockwise/counter-clockwise.

i. The leg moves most freely in an anterior/posterior plane and experiences decreased range of motion in the other orientations; however, it supports the weight of the upper body and the coxal provides necessary solidity

ii. The arm moves in a much more flexible manner (greater range of motion in all three directions) and hangs freely at the sides

The students are then able to conclude that in the arms, where greater movement is called for, the point of attachment includes in its design a linear/tubular bone, the clavicle. In regions where movement and activity are called for the body employs these linear/tubular bones and synovial articulations (see figures 1 or 2, again). In comparison, the leg must serve the body as a structural support, bearing the weight of the body against the resistant force of gravity. Thus, in the leg, the body employs: fused plate-like bones that encourage solidity and stability, with the compensation of less flexibility and movement. So, while the clavicle may seem to interrupt the recurring patterns of polarity in the human skeleton, it actually serves to further confirm its influence through out the body's regions.

Further Application in Comparative Anatomy

Often this activity can be completed over the course of one period, or spread out over two days if it is not begun at the start of the Main Lesson period. Usually this activity serves as a foundation that is continued in a study of the hand and foot–perhaps the most complex morphological sub-region of the human limbs. However, this activity also serves as the basis for a comparative anatomical study of vertebrate skeletal structure in the third week of the course.

Using a further sequence of observation-based activities focused on the hoofed mammals, the students conclude that the animal and human share a similar limb structure. The *limb pattern* is not only good for humans, but for all vertebrates! However, human limbs are certainly not the same as animal limbs in their development or adult structure.

At least two clear differences stand out for the students almost immediately. First, the animal leg is clearly different in that it is proportionally emphasized in the distal region, while the human limb has a greater proximal proportion—yielding a more balanced, functional form. Second, looking at the limbs from a paired perspective: front and rear limbs, the human limbs are regionally unique, while the animal limbs are regionally quite similar. Many animals have generally similar front and back distal limb structure: paws or hooves, while the human does not.

Once clear differences have been pointed out, it is healthy for the student to become very clear about the actual similarities, since after clearly describing these differences it seems that it is quite remarkable there are any similarities at all. Both human and animal limbs have similar placement of tubular bones and moveable joints, the limbs typically have three regions, and of course the bones have similar composition, chemical and otherwise. The students can be prompted through review questions to conclude that the same was the case with the skulls of animals and humans when they studied them the previous week.

The fruit of this pattern recognition process, the clear and living understanding of the form and organization of human limbs, can then be used be used as the perceptual basis

for some challenging, but appropriate initial concepts about the relationships between the human being and the animal. The skeletal structure of the limb of the human being is organized in a way to maintain flexibility and balanced proportion, while the skeletal structure of the animal limb has been fused, joined, immobilized, and generally specialized in a manner that compliments a specific form of behavioral expression. In a way, the human being can be thought of in a balancing, central position among the animal kingdom, with the diverse collection of specialized animal types spread out around that point of balance.

Developmentally, the human being is held back from a fixed state of adulthood representative of animals, where little growth or learning continues past the age of sexual maturity. In this way, the animal is developmentally more complete at the age of sexual maturity; much or all of its instinct-development and learning takes place before that point. The development of a culture of learning, of art and technology can then be seen as closely associated with the human being as a life-long learner.

It seems very reasonable that the forces which normally go into physical formation in the animal, are used to develop other capacities in the human being, including individual thinking, free choice, morality, and spiritual vision. However, while great opportunity is a natural outcome of the development of these unique characteristics, great obstacles or challenges of discipline, responsibility and self-sacrifice become equal companions on the road of human development.

With each student group, these concluding ideas are formed in a unique manner and the point is not to make sure they are all brought to life through the activity of the group, but rather they give an example of where adolescents might go with experiences gleaned through pattern-recognition. To better understand and explore these ideas about the relationships of human beings and animals, a reader may reference some of the author's favorite titles in the bibliography below, under the subtitle: "The Overall Human Form and Comparative Morphology."

Conclusion: In the students' words . . .

The educational process of pattern recognition is clearly challenging, but the students have some real successes. There is no question of whether the students can do this. They certainly can do this, quantitatively and qualitatively, but how much and to what extent is the question. It is merely a matter of keeping the level of study (structural, functional, developmental, evolutionary) not necessarily the nature of study (quantitative, qualitative) appropriate to the developmental level of the class. Generally, most ninth grade students have been able to recognize general, structural patterns—previously described elsewhere– in a new but related experience. This is often tested at the end of the course, when the students are asked on the final quiz whether the patterns of polarity evident in the form of the skull or limb are present in the hand, a region the class has usually not studied as a group in the same manner as the skull and limbs. The following is a passage from one ninth grade student's work.

> "The main similarity between the skull and the hand it that both have a region of non-moving, plate like bones that provide stability, with an attached region of linear-type bones that are moveable. The moveable bones of the skull and hand are similar in this way, yet they are different in their structure in an important way. The mandible is attached to the skull at both ends, which limits its movement but increases its strength, while in the hand, because its part of a limb it has its moveable bones connected at only one end. This provides less strength, but great flexibility and movement."

This work with pattern recognition provides the solid basis of observations with which to create and apply the concepts of bodily specialization and lack of specialization to help substantiate and clarify the general theme of balanced, proportionate form in the hu-

man being. Again, questions from the last quiz of the course are used to test the thinking of the ninth graders. The following is a passage from a different ninth grader's work.

> "Human bodies are built in such a way that they can do a wide variety of things, depending on how the body is worked and taught to do something; humans are not meant to do one thing in particular. Humans walk upright, which leaves their arms (with opposable thumbs) free to grab, lift, and move things. Humans can also speak, which opens up many more windows of opportunity to them for a choice of occupation."

As a teacher it is exciting to share this type of inquiry with students. It is often difficult for them, just as learning any new skill carries with it trials and obstacles, and it does not often fit the category of "education as entertainment," as so much "whiz-bang" science does these days. However, it is rewarding and the students gain real insights, the kind of insights that are "living" just like the organisms they help to portray.

Bibliograhy

1. Rudolf Steiner introduced the term "Earth Ripeness" for example in *Soul Economy: Body, Soul, and Spirit in Waldorf Education*, 16 lectures in Dornach, Switzerland, Dec. 23, 1921-Jan. 7, 1922 (GA 303) [previous title: "Soul Economy and Waldorf Education"]

2. Martin, Michael. *Education through Arts and Crafts*, Forest Row, England: Steiner Schools Fellowship Publications, 1999.

3. Mitchell, David and Patti Livingston. *Will Developed Intelligence*, Fair Oaks, CA: AWSNA Publications, 1999.

4. Craig Holdrege discusses the stage of "*logical thinking anchored in observation*," in "The Art of Thinking: Helping Students Develop a Truly Human Capacity," *Renewal*, Vol. 10, #2, Fall/Winter 2001, pp. 28-31.

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