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ABSTRACT

This paper argues for extending the definition of "technology" in education to include much more than just computers, and for recognizing the dangers of using technology for its entertainment purposes. Two conceptions of the proper use of technology in science classrooms are offered: (1) technology as tool; and (2) technology as topic. Specific examples of the use of technology as a tool and as a topic in high school biology and chemistry classrooms are presented. (Contains 51 references.) (WRM)

Approaches to Technology in Biology and Chemistry Classes: An Alternative Perspective

Charles K. Jervis

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There are many approaches to using technology in science classes. How one uses it depends on one's attitude toward technology generally and technology in education specifically. Two attitudes which are common in the popular mind have been frequently reflected in statements or actions by even rabid educational technophiles.

First, an increasingly common attitude is that technology is synonymous with computers. Fortunately, at Auburn High, many of us do not have this attitude. We view technology in a broader perspective---CBL's, spectrometers, probeware, robotics, hardware, software, peripherals, cameras, videos, laboratory instruments, industrial arts equipment and so on. Many people with such broad based views are on committees in key positions to attempt to ensure wide leeway in integrating technology into classes. Unfortunately, sometimes those who control the purse strings do not share this open view.

Recently we were faced with opportunities to purchase technology which we had determined we needed to enhance our program. One of the items we had planned to purchase was an editing board to use for video editing by our students. For years students have had the project option of turning in a video tape as a product component of their portfolios. The quality was highly variable and we hoped to use the editing board to improve student products. A purchase order was written and "sent up the line" only to be returned with the comment that the funds were for computers . Although there was no explicit statement of this in any documentation we knew of prior to the request, from the return of the PO it was evident that this was the definition by those who had provided the funds. Of course, if that was specifically what the funds were given for, then the return of the PO was understandable. However, we had felt that technology was more than computers.

A similar attitude is often expressed in state or national rhetoric from policy makers when "technology" is equated with "computers". We need to be vigilant to assure that definitions as Shallis' (1991) which covers more broad areas as well as processes are used. As is illustrated in the works of Henry Petroski, such as The Evolution of Useful Things (1994) or more strongly addressed in Stoll (1995, 1996), technology is more than just computers. As Shallis (1991) has said, technology is more than "Silicon Idols" and universal connectivity to the WWW. Indeed, in many areas, as discussed briefly by Hudson (1999) , a more broad based definition and subsequent integration is becoming evident. With this prevalent narrowly viewed definition of technology comes an attitude which is often reflected by the use of computers---that is "technology" as an add on toy. [For expression of this idea and the next two, I am indebted to the articulation made by Zeran and Carnes (1991) and their collection Questioning Technology: Tool, Toy or Tyrant.] Recently I heard two of my most technophilic colleagues relate how their recent acquisition of computer and web based resources gave them "new toys" which were "fun to play with". I have heard this statement often, from teachers, administrators and students. For years I have corrected students when they ask, "Can we play with your computer ?" Fortunately, I hear this less often these days. Unfortunately, I still see too often reflected in student use the type of play characteristics or habits of mind which are associated with those described by Healy (1998):

Impulsivity

Trial and error guessing

Disregard for consequences

Expectation of easy pleasure

all of which lead to wasted time and opportunity.

You've seen it too, I am sure. At the keyboard, or with the probeware, or camera, or saw and planer---people play. Now, play per se is not always a bad thing. Even in this era of high stakes testing where, in some situations, day-to-day activities are heavily structured for test preparation, one might still be able to make a case for play. The question is, however, when thousands or hundreds of thousands of dollars have been spent on narrowly defined technologies, is play an effective, not to mention, cost efficient, way to use it ?

Yes, computers and other technologies, because of the influence of the entertainment industries and the video game / television predisposition students have, lend themselves to intentional or unintentional play mentality. Especially today with many Web based resources, glitzy with graphics and animation, the message can get lost in the medium. As attention waivers, although apparently engaged in the task, disengaged students fall into the play mode, mentally and physically. We must be wary, as Gozzi (1995) points out, not to overemphasize entertainment, the toy aspect, of technology, computers and otherwise. As Katz and Chard (1989) note, enjoyment may not be an entirely appropriate goal of education. Neil Postman, in Amusing Ourselves to Death (1985), has extensive discussion of entertainment mentality and its effects on education. Gozzi (1995) is correct in saying that what Postman says about television is easily applied to other media, especially computer based applications (CD's, Web Based, Hypertext, etc). An over emphasis on technology because it makes education more fun and more actively engages students (a dubious assertion) can clearly be harmful as Healy (1998) has extensively examined.

Thus, one may ask, after we've extended the definition of technology to include much more than simply computers and recognized dangers in using it for its entertainment / toy purposes, what are some of the proper uses for technology in science classes ? I offer two, which I again reference back to the title of Zeran and Carnes (1991), technology as a TOOL and technology as a TOPIC. It is these two areas which I wish to address in most of the remainder of this presentation.

I am sure for all present, technology as a tool is both an expressed and practiced philosophy. As some of these sessions illustrate, using technology (albeit mainly computers or computer based in many cases) to facilitate data acquisition, analysis and presentation are common themes. Using probeware with interfaces to analysis software is common. Using word processors, spreadsheets, databases, presentation software, drawing programs and increasingly modeling programs is also common. These tools often seem to engage children's minds. We must be careful, however, to remember what Katz has been quoted as saying : " Just because children do something willingly, even eagerly, is not sufficient reason to believe it engages their minds." (Stoll, 1995).

Especially with regard to computers, we need to be vigilant. Healy (1998) has noted that "There is no proof, or even convincing evidence that it [computers in education] works" [with regard to student learning]. One does see reports, such as Conyers et. al. (1999) which report that technology [computers] can transform a school. However, in this case, and in others upon closer examination, so many variables change in many studies that to make a definitive conclusion about the benefits of technology is hasty at best. One also needs to remember Mander's (1991) admonition " Since most of what we are told about new technology comes from its proponents, be deeply skeptical of all claims."

So it is with this in mind---that technology should be a means to an end, a tool to be managed as Tenner (1997) describes and in so far as science education is concerned, not an explicit goal in itself [more on this later], that I describe technology use as a tool in an integrated biophysics project supported in its development by a Toyota Tapestry grant.

Recognizing a need to make biology classes more mathematically oriented and reflect a broader view of application of biological understanding as well as to enhance physics classes' applications beyond traditional engineering examples, the physics teacher and I submitted a proposal for funding to develop inquiry based investigations of biological phenomena from physical science perspectives. Those inquiries involved several different technologies, none of which used desktop microcomputers for data gathering. One which I'll describe was decidedly "high tech" because it uses electronic data gathering hardware, but not interfaced with a microcomputer, and another will be described which uses decidedly low tech tools / technology.

First, the high tech one---energetics and human power. I am sure that many of you have done this lab or one similar to it. Have students determine their weight , run a measured distance up a flight of stairs, time the ascent, then use formulas for work and power to analyze energetics in some way. Analysis reflects the hypotheses generated before doing the lab, (e.g. Males > Females, Athletes > Non athletes, Morning > Afternoon) , there can be many but they were based on pre lab readings or discussions about muscle function and energetics. We related this activity to human kinetic energy production which was related to muscle function and oxygen use. A question arose about the relation of oxygen consumption to anaerobic muscle activity. Eventually, a related variable was identified, blood oxygen content, or % O_2 .

[Discussions of NOVA videos, "Coma" and "The Death Zone", with visits to various Web sites and library based research on Carlos Monge and altitude sickness were also included in this particular unit. A historical perspective was available from Diaz (1996) in which Cassion Disease is discussed]. Students realized that it is useful to measure blood oxygen content. Here the new technology came in when we acquired with the grant's funding relatively inexpensive Pulse Oximeters. These devices allow rapid pulse measurements and % O_2 saturation of the blood. Students generated hypotheses about oxygen saturation before and after physical exercise.

This non-invasive technology is not new. It can be found in hospitals, clinics and physiology research labs. This use in high school biology labs, in conjunction with physics investigations and discussions of chemistry principles may be new. In many ways these devices exemplify some admirable qualities which other technological tools should show. They are relatively cheap (when compared to something like a desktop microcomputer and associated probeware). Admittedly, they only do two things, but they do it cleanly and crisply with minimum user training. They also have the advantage of being a focused tool--this means that it is difficult to waste time playing with them. It is much easier to say of them that they are for specific and clearly defined educational purposes only.

A second, decidedly low tech way we used technology as a tool was in arm function modeling. Of course, one may, as illustrated by Pagonis et al (1999), use the microcomputer based Interactive Physics software to do this. Clearly, there will be advantages to using the high tech way in modeling. I am fairly sure that we will add it to our available tools sometime in the future, but probably as an adjunct to rather than replacement of the modeling assignment we used in the Toyota Tapestry Biophysics Project. An extensive description of the whole project is beyond the scope of this brief presentation. A summary will have to suffice.

Here we have a model developed by a student from which measurements can be made and variables identified with regard to lever systems in human arms. The technology here is obviously low tech--scales, rulers, protractors, calculators (optional), a saw and hinges, some nails, hooks and wheel and axle.

With this device, my hypothesis, not yet tested, is that anyone who understands this model will have a level of competence equal to one who uses the Interactive Physics modeling program. It would be an interesting research endeavor to see if this is supported.

I use these two examples to show how technology as a tool can be approached. From the outset I tend to agree with Wendell Berry (1996) when he cautions that new technologies should be viewed in a holistic light relative to the ones they replace. With a clearly defined goal---investigating relationships of forces in arm functioning--the jury is still out on whether a computer simulation is better than this one. For that matter, there is some disagreement about computer simulations in general. This disagreement is reflected more eloquently than I have stated by Mary Clagett Smith (1996) "The original, tactile, responsive world of sand, mud, water, grass and Teddy Bears is rapidly being replaced by screen simulation. Children are learning the basics second-hand--from two screens, the T.V. and the P.C." Her attitude is supported by many others, notably Stoll (1995) , Postman (1985) and Healy (1998).

I use these two examples for another reason, to show that technology as a tool is integrated into the activities--not an end in itself. Data gathered were organized, analyzed and presented using technology--low and high tech. Word processors, spreadsheets, graphical analysis, HTML, printers, rulers, graph paper, calculators--these were all used at one time or another in facilitating student investigations and analyses. Although not central to the investigation, technology as computers was a tool, perhaps not a necessary one though.

There were other technologies involved in the Biophysics Project--- LASERS, force sensors, thermometers, balances--- but they were deliberately kept low tech when possible--to place the least between student and sensory observations. We consciously endeavored to assess appropriate use in determining what technology to use. It is in this area, assessing technology impact on intended goals and its appropriate use which is at the foundation of the next major approach to technology that I want to cover. That is as a TOPIC.

Having attempted to refine the definition of the TERM, examined its use and potential misuse as a TOY and suitability as a TOOL, we now enter a discussion of technology as a TOPIC. It would be easy to write a book on this---indeed many have been written: Florman (1981), Healy (1998), Henderson (1996), Mander (1991), Porter (1980), Shenk (1997), Zeran and Carnes (1991), Stoll (1995) and Tenner (1997) are just a few. What many of these have in common is the field or idea of technology assessment, and sometimes a related field risk assessment. These areas form the core of a project developed with support from the Virginia Foundation for the Humanities and Public Policy (VFH) and elaborated more fully than here in Jervis (1999).

In the VFH fellowship program examining science and society, I was fortunate to hear a number of speakers address technology and science issues. James Trefil, Doris Zallen, Joseph Pitt, Deborah Fitzgerald and Daryl Chubin all initiated discussions on and raised questions about what type of relationship exists between science, society and the common interface between the two, technology. About the same time I was reading The End of Education: Redefining the Value of School (Postman, 1995). It was Postman's "The Word Weavers / The World Makers" and his identification of technology as a "god which had failed" in education that further spurred my interest. Further reading on my part indicated that others, at least in part, held similar views. Healy (1998) has noted that "as a culture we increasingly esteem technological intelligence and devalue social and emotional intelligence." She reflected an attitude toward computers not entirely dissimilar from that expressed more elaborately for other areas of human activity by Robert Turner (1996). Of course, there were numerous examples of middle of the road, right or left wing political and philosophical responses to the same issue. Florman (1981) and Petroski (1994) give a useful, generally "pro technology" views, Mander (1991) and Postman (1985) give different views. Stoll (1995) addresses computers and the WWW directly as do Healy

(1998) and Shenk (1997). More "technical" approaches to technology assessments or risk assessments can be found as part of the CEPUP (1990) project, Project Learning Tree (1998), Rosenberg (1988) and Morgan (1993).

Attention to technology analysis and technology / risk assessment is frequently seen in the popular press. Newspaper accounts about hazards in life [Hazards Associated with Super Roller Coasters (Associated Press, 2000)] side effects of gene therapy [Side Effects Seen in Gene Therapy Trials, Roanoke Times, 1999] or op-ed pieces such as Dunaway (1999) or McCreary (1998) or Stoll (1995) and magazine articles such as Colino (1999) and Ryan (1997) are recent examples. These stimulate student interest and spark support for treating technology as a topic. As Bill Gates (1995) has said:

"It is important that both good and bad points of technological advances be discussed broadly so that society as a whole, rather than just technologists, can guide their direction." I have included in your handouts examples of assignments which students in my classes do in order to develop critical thinking skills with regard to technology use.

Clearly supported by the national standards [National Science Standards--Content Standard E; National Social Studies Standards--Performance Expectations-High School-F], state standards [Virginia Social Studies Standards 9.5e, 9.7f, 9.9b, 9.10 Figure 77; 10.2b, 10.3d, 10.9; 11.1a, 11.8b, and 11.c] , and Benchmarks for Science Literacy (Project 2061) technology as a topic through technology analysis and assessment with a strong social and historical component [Goodman in Henderson (1996), Postman (1995), Florman (1981), Tenner (1997) and Diaz (1996)] offers an excellent opportunity to link content and process across disciplines. Such a study can incorporate other technologies as tools and enhance understanding of science content, process and impact.

We have thus far defined the TERM, discussed the perils of the TOY, the benefits of the TOOL and the possibilities of the TOPIC. This leaves a related "T" as mentioned earlier in Zearn and Carnes (1991)---TYRANT. An elaborate discussion of that area of technology will have to wait for another day. It is in this area that deeper philosophical discussions of whether it is more appropriate to shape ourselves to technology or to shape technology to our needs can be held. Do we use the tools or become used by the system which supports the tools ? Are we simply tool managers as Tenner (1997) has described ? To what extent should we transcend current stresses to incorporate a particular technology, perhaps inappropriately, or to what extent should we conform for some unknown future ? Gozzi (1995) addresses some of these issues from the edutainment point of view as does Postman (1985), Stoll (1995), Healy (1998), Levy (1997), Neill (1995) and others. It may well be, as some have said, with regard to technology in the classroom, that we are in a transition period. One may take either an optimistic view (e.g. Gates, 1995) or a more pessimistic view (e.g. Postman, 1985) about the appropriateness of what we do with it at any particular time. More meaningful discussions need to be held about this area in particular and all areas of technology in the classroom in general.

As we have seen , there are many approaches to using technology in the science classroom. We need to balance education with training , broad technology applications and definitions with specific applications, the serious use with the fun, seeing it as topic ---or tool ---or tyrant.

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Explore Park Study Guide Name________________ Date____________

A. Describe the technology by which the Native Americans preserved:

food ____

leather ____

wood ____

B. Describe the technology by which the frontiersman

started a fire. ____

preserved hides ____

manufactured cups and bowls ____

C. Describe the technology of how the Appalachian settlers

fertilized gardens ____

preserved food ____

dyed fabrics ____

D. Describe the chemistry and technology of the metallurgy involved in making wrought iron: ____

As we have studied, science produces knowledge. It produces frameworks of understanding which explain observations in a consistent manner. If the frameworks are accurate, they allow for not only explanations but also for predictions about behavior of the universe. When we apply these frameworks of understanding to producing a solution to a particular problem, we are developing technology.

The technological applications of scientific understandings can be used to better humanity. Sometimes, these technologies have literally changed the world by producing a profound effect on how we do things. Your assignment is to investigate the <u>science</u> of a selected technology. Ideally, it will be one of your own choosing. Below is a partial short list of some possible areas of study:

- Artificial Sweeteners
- Photovoltaics
- Synthetic Dyes
- Rechargeable Batteries
- Chemical Leavening
- Glass Making
- Semiconductors
- Hydrocarbon Fuels
- Chloroflurocarbon Refrigerants
- YBaCuO Conductors
- Antibiotics
- Herbal Medicines
- Lumber Preservatives
- Printing and Inks
- Gunpowder(s)
- Metallurgy
- Artificial Flavors
- Xerography
- E. H. Land Photography
- Food Preservatives
- Catalytic Converters
- Chelation Treatment
- Fluoridation of Water
- PCR
- Nylon or Synthetic Polymers
- Hygiene
- Textiles and Fibers
- Paints
- Leather work and Tannery
- Fertilizers

You are to select one of these or an approved one of your own. You are to begin putting together a portfolio of background information on the topic. In the portfolio you must include at least :

1. An Encyclopedia Article
2. A Magazine Article of some type
3. A WWW site URL with print out
4. Chemistry text or journal documentation

In all you want to gather as much meaningful information about the topic as you can. You will be using these materials to answer at least the following questions:

1. What is the technology you are investigating ?
2. What is the basic chemistry involved in it ?
3. Who are or were some individuals involved in using or developing it ?
4. Why was it developed ?
5. What are some costs associated with it ?
6. What impact has it had on society ?
7. What are some safety issues associated with it ?
8. Is the technology fully developed or still under development ?

You have information and background you need to complete a technology assessment. Such an assessment is often a component of a risk analysis. These activities are components of wise business practice. In engineering or business schools, training in some aspect of technology or risk assessment is often required and one might be expected to be part of a team doing such assessments. These activities are especially important in the chemical industry or in applications of biological discoveries. The technologies you have investigated can be assessed using the information you have gathered and organized.

Your final assignment is related to the 14 questions assigned in the beginning. You are to prepare an oral presentation which addresses these questions:

1. What is the technology you are investigating ?
2. Summarize the background science involved in it ?
3. Who are (were) some individuals involved in its development ?
4. What problem was it developed to solve ?
5. What are some costs (economic, cultural, environmental. etc.) associated with it ?
6. What are some benefits (economic, cultural, environmental. etc.) associated with it ?
7. Are the costs and benefits certainties or future probabilities ?
8. What are some safety issues or questions which are associated with it ? Have they been addressed ? Are these certainties or potentialities ?
9. Is the technology fully developed ? If not (and most of them you have investigated are not.) what are some future developments or problems which need to be addressed ?
10. What would an extremist Luddite say about your technology ?

Your product will be an oral report with script (clearly written or typed). The oral report will be assessed by the attached rubric. The script must contain the answers to each of the above questions and a complete proper bibliography. The time limit for the oral report component will be no more than 15 minutes and will be given Wednesday, Thursday or Friday next week or Wednesday and Thursday after the 17th. You need to register for presentation slots on the sign up sheet in class. If you are working with someone in another class, see me for modifications to the presentation schedule.

Biophysics Connections

A Project Supported by the Toyota Tapestry Grant Program
and
Auburn High School
Montgomery County Virginia

Presented by
Charles K. Jervis

Heat Productions and Transfers

By this time you should have read the Haldane (1985) essay [which was actually written much earlier, but reprinted in a collection in 1985] *On Being the Right Size*. If you haven't, you should because much of the reasoning in this section is based upon an understanding of the relationship of surface area to volume ratios. Any introductory biology text book will have information on this concept and Biggs *et al* (1995) and Campbell (1996) are no exception. You should also have read the information on the topic in these as well . Press (1980) takes Haldane's ideas and stretches them to interesting physical and cosmological limits concluding we are the size we are for three very fundamental reasons. If you are interested in exobiology you may want to read his article too.

Energy is required to maintain homeostasis, the balance among all life processes. As we saw earlier, this is especially true in movement of an organism or material within an organism. Since energy transfers from place to place or conversions from form to form are less than 100 % efficient, that is in all transfers some "useful" energy is lost, as described by the laws of thermodynamics, some of the energy ends up as heat. This production of heat can mean a change in temperature of a living system. For all biochemical processes, especially those mediated by the functions of enzymes, there is an optimal temperature range within which life can exist. This varies from species to species, reaching notably low or high temperatures in the groups known as extremophiles. Generally, however, it is as Davidovits (1975) notes, since life as we know it depends on the presence of liquid water, and since under prevalent atmospheric pressure water is liquid over a relatively narrow range of temperatures (~2 to 100 ^{O}C), it is important that organisms have ways to prevent exposure to temperature outside their optimal ranges. For most organisms the range at which metabolic processes can occur is much narrower than the range for liquid water.

In humans for example, the generally accepted "normal" core body temperature is taken as 37 °C. Davidovits (1975) and other sources point out that a drop to 28° or a rise to 44° will be generally fatal. There is some interest in variations in this range which are of important research focus. This has been discussed in the readings about the diving reflex (NOVA Video (1996) Coma). Death at temperature extremes results from denaturation of protein enzymes which facilitate metabolic processes at life friendly temperatures. Extremophiles have evolved different enzyme systems more tolerant of high and low temperatures.

When studying organisms, from a biophysical perspective, of interest are four things:

- Where do they get the energy they need ?
- How do they use the energy to maintain life ?
- How do they store the energy for later use ?
- How do they control energy flow ?

In this section of our Integrated Biophysics Study, we will concentrate upon the last of these. As we shall see, however, all four will enter into a complete understanding of heat production and transfer. From a physical science perspective, we are examining thermodynamic principles applied to living systems.

General reviews of the relationship between **heat** and life can be found in Davidovits (1975) Chapter 11, "Heat and Life". In it he gives a concentrated discussion of the four areas listed above relative to humans. Where we get it (from food, fuels and sun); How we use it (metabolism and thermal homeostasis); How we store it (fats when intake > output); How we control it (Conduction, Convection, Radiation, Evaporation, Insulation and Shivering). Marion and Hornyak (1985) in their essays dealing with metabolic rates of humans and other animals also review some fundamental relationships among these four areas. In both resources the relationship between surface area to volume ratios is stressed since this is one of the most basic physical factors to influence rates of heat gain or loss.

It is important to emphasize the specifically physical nature of the relationship of surface area to volume ratios in heat control (and therefore temperature control) since there are numerous behavioral adaptations which assist in control. These are summarized by Barnes (1991) and Suter (1984). However, it can be noted that these behavioral responses often work because they alter surface area to volume ratios. For example, in basking to warm up, many cold blooded animals (ectotherms) are increasing the surface area exposed to the heat source to increase the rate of heat gain. In gaping or panting to cool off, warm blooded (endotherms) non sweating animals are increasing the surface area from which evaporation can occur in order to increase the rate of heat loss.

Countercurrent heat exchange mechanisms, one of the most efficient anatomical control mechanisms in animals, is discussed by Biggs *et al* (1995) and Campbell (1996) in general and more specifically by Franklin and Plakke (1988) who also describe a method for modeling the system. This involves structures which function on the principles of thermodynamics to transfer heat, especially obvious in polar animals such as polar bears and penguins that conserve heat using this mechanism (Barnes, 1991).

Obvious, I hope, are the important clinical implications of these principles of heat transfer control and thermal homeostasis. Weinstock (1980) extensively discusses one such application. For many, also evident will be the economic and technological applications to an understanding of these principles in physical activities. From design of clothing for optimizing heat transfer or retention to training of long distance swimmers and nutritional programs for endurance event participants, an understanding of the four areas of concern, especially heat control, are important.

The Heat Transfer Labs

The laboratory activities which Mr. Rencsok and I have designed for you in this section of our Integrated Biophysics Study deal with some factors which control rates of heat loss and gain in living systems. As before, we will model these systems or components of them. As always, you need to be consciously aware of the limitations of these models. You need to also be able to interpret the observations from these physical models in terms of the biological importance. Franklin and Plakke (1988), Barnes (1990) and Suter (1984) all give additional information, examples and models which will prove useful in increasing your understanding of the importance of heat control mechanisms in biological systems.

Scientific American Articles:

1965	Aug	Dawkins and Hull	The Production of Heat by Fat
1965	Dec	Gates	Heat Transfer in Plants
1967	Sep	Ziman	The Thermal Properties of Materials
1969	May	Tucker	The Energetics of Bird Flight
1972	Mar	Margaria	The Sources of Muscular Energy
1975	Jul	Wurtman	The Effects of Light on the Human Body
1978	Aug	Heller et al	The Thermostat of Vertebrate Animals
1979	May	Baker	A Brain Cooling System in Mammals
1981	May	Schmidt-Nielsen	Countercurrent Systems in Animals
1984	Aug	Mandoli and Briggs	Fiber Optics in Plants

Other Resources

Barnes, George. 1990. An experiment on area-to-volume ratios. *The Physics Teacher.* Sept. 1990. 403-405.

Barnes, George. 1991. Nature's heat exchangers. *The Physics Teacher* Sept. 91. 330-333.

Biggs, Alton; Kapicka, Chris; Lundgren, Linda. 1995. **Biology the Dynamics of Life.** Glencoe / McGraw Hill, New York City, New York.

Campbell, Neil A. 1996. **Biology** (4th edition). Benjamin / Cummings Publishing Company, Inc. Menlo Park, CA.

Davidovits, Paul. 1975. **Physics in Biology and Medicine.** Prentice Hall, Inc. Englewood Cliffs, NJ.

Franklin, G.B. and R.K. Plakke. 1988. Countercurrent heat exchange in vertebrate limbs. *American Biology Teacher.* 50(7): 452-455.

Haldane, J.B.S.1985. **On Being the Right Size and Other Essays** Oxford University Press. Oxford. Pages 1-8.

Marion, Jerry B. and Hornyak, William F. 1985. **General Physics with Bioscience Essays.** John Wiley and Sons. New York.

Press, William H.. 1980. Man's size in terms of fundamental constants. *American Journal of Physics.*. 48 (8):597-598.

Suter, Robert B. 1984.Wasp Work: An Anytime Study of Summer Processes. *American Biology Teacher.* 46 (1):18-21.

Weinstock, Harold. 1980. Thermodynamics of cooling a (live) human body. *American Journal of Physics.*. 48 (5):339-341.

Standards Addressed by Integrated Biophysics Study

Virginia Standards of Learning

- Bio 1 Laboratory investigations and data analysis and presentation
- Bio 3a Water properties
  - 3b Macromolecules
  - 4d Modeling membranes
  - 5d Homeostasis
- Physics
  - PH 1 Laboratory investigations and data analysis and presentation
  - PH 2 a Physical problem translated into mathematics
    - c Slope and linear relationships calculated
  - PH 4 a Science in the real world
    - b Science and technology
  - PH 5 g Work, Power and Energy
  - PH 11 a Refraction
    - b ray diagrams
  - PH 12 Inverse square law
  - PH 14 i Radioactivity

National Research Council National Science Standards

- Physical Science Content Standards B
  - Motions and Force
  - Properties of Matter

Project 2061 Science for All Americans

- Demand for Evidence (p 4)
- Explain and Predict (p 6)
- Social Activity (p 8)
- Patterns and Relationships (p 16)
- Engineering Combines Science and Technology (p 27)
- Energy Transformations (p 49)
- Motion (p 52)
- Flow of Matter and Energy (p 66)
- Basic Human Functions (p 76)
- Materials (p 111)
- Communication (p 118)
- Health Technology (p 123)
- Summarizing Data (p 137)
- Sampling (p 139)
- Change (p 172-177)
- Scale (p 179)
- Habits of Mind (Chapter 12)

Arm Functioning Model

Due October 30th

Your team is to construct a model of the movement of the forearm by the biceps muscle. Your model should consider the following characteristics:

Forearm bones portrayed
Upper arm bone portrayed
Biceps muscle with tendons portrayed
Point of attachment of biceps accurate
Counter balance of the lever system(s) involved portrayed
Relationship between resistance and effort observable

Using the materials available in class, the model should be able to demonstrate arm movements and mechanical advantage.

You should research the sizes of the bones involved, the range of , movements involved, the angles involved and the points of attachment for the tendon(s) and the fulcrum.

Remember:

"Models do not have to look like the real thing. They just have to act like it."
SFS

Mechanical models are certainly acceptable, but you might also consider graphical, video, computerized or mathematical models as well. If you are so inclined, you may want to locate the Davidovits or the Marion and Hornyak books we have referred to and read their presentation of the formulas involved in describing this type of motion. From there, your group might be able to put together a computerized model. In such cases, exemptions from the physical portrayals will be given.

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