Stream Ecology

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TABLE OF CONTENTS

Introduction

Dave Harbach

A warm moist breeze, on a cloudy midsummer morning, moved gently over the plants, animals, and gurgling springs of Silver Creek. A little further downstream near a riffle, red cup fungi grew amongst green moss on a fallen tree trunk, while light green duckweed floated in a pool area off to the side of the shallow stream. Tiny frogs in abundance jumped, sat, and crawled among the marsh marigolds and the hundreds of other flowering aquatic plants that covered the small flood plain. Into the midst of this serene beauty came the expressive sounds of “This is a neat place!” “Where’s the Muscol?” “Yuckoo! What’s that green glob? Oh, gross!” “pH is 7.8 with a water temperature of 9.1 degree C.” “This is a riffle with springs, gravel bottom, and 21 cm deep.” “I see caddis fly larvae, spiral snails on the bottom of those rocks.” “Hand me the net.” “Hey, a small fish!” “Ew! Ew! I’m not touching that ugly thing!”

Who made these excited sounds? These were not the words of a class of high school students but instead the emotion-packed vocabulary of three older and very enthusi astic science workshop members studying a stream in vivo.

Why were they studying a stream? The answer is simple: we were practicing what we intended to “preach” and were trying to find out by experience what a teacher would need to do in order to organize and conduct the student study of a stream.

Why take a group of students outdoors to study a stream? Why should they study a stream? What things will they study and who will study them? These questions and others we hope to answer in more detail in this practical unit on stream ecology. As my colleagues might say, “Be prepared to have your socks blown off.” Or should it be, “Be prepared to get your feet sopping wet!”

Chapter 1

Why?

Why Study Stream Ecology Outside?

Dave Harbach

The meaning of the words "stream ecology" will help us to arrive at a proper answer to the question: "Why go outdoors to study a stream?" In his book, *Ecology of Inland Waters and Estuaries*, George K. Reid states in his introduction on page 2, "The word derives from the Greek noun for 'home' (*orkos*), and, in its present spelling and meaning, ecology is the study of the relationships between an organism and its environment… The term environment in the definition refers…to the physical, chemical, biological features of the habitat, or locality, in which the organism lives." From this we gather that in order truly to study a stream we must actually go to a stream if we wish to investigate the relationships between organisms and their environments in the stream. Each stream has its own particular environments and organisms or, if you will, its own personality which varies greatly with other streams. We must go outdoors to the stream to understand the unique personality that God has given it.

Striking as it may seem, there are universities that divert the stream into the classroom environment for carefully controlled studies. But this is not practical for the elementary or high school setting. It might be exciting to have a stream flowing through the classroom but this is not feasible in a classroom environment where space is at a high premium. What teacher is going to lug hundreds of gallons of water and tons of soil, plants, and animals into the classroom? Besides, the students need to venture outdoors because that is where God has put the special classroom setting to be studied, a setting that only God can create and maintain by His will.

But, you might object, isn't the artificial stream setting of books, black boards, bulletin boards, movies, filmstrips, drawings, etc., and stream environment captured in a jar enough? Why waste precious classroom time going outdoors to study what you can already learn about from books, celluloid, etc.? And, in addition, what student has not already, on his own, spent many hours enjoying the outdoors in play or in inquisitive investigation of God's creation?

Let us read what some experts think.

To quote Mark Terry on page 11 of his book, *Teaching for Survival*, An Intext Publisher, New York, 1971, "…The environment quite easily becomes the printed page, the earphone, the TV screen, the movie. They all describe the real world, which we lose the ability to sense for ourselves…"

Terry also writes on page 16, "The need for teachers to return to their own education and to become sensitive to the environmental implications of their own methods and of the materials they use: this need can never be emphasized enough. In terms of the environment a misinformed teacher is a dangerous teacher…"

"No better teaching materials for young or adults are available or easier to find than aquatic organisms. They are equally useful for research materials and the delights of discovery await all who dip into the water to find them…" (from the preface of *A Guide to the Study of Fresh-Water Biology*, by James G. and Paul R. Needham).

Another quote from the Needhams: “Field trips to collect the organisms and to analyze the characteristics of each type of aquatic environment selected for study will form the basic core of training for students” page 79.

“All of them become more meaningful if combined with field trips where the students can view each type of aquatic habitat and aid in the collection of materials for the indoor laboratory to follow” page 102.

The need to take our students outdoors to the real thing is so that they study in an organized manner what they haphazardly experienced before in play and inquisitive investigation. By going outdoors we teach students how to become effective investigators of God’s creation, using the senses God has given them to be faithful kings who rule over the earth with wisdom.

There are, fortunately, and you are probably one of them, many teachers who know the educational value of taking children to the outdoor classroom. These teachers frequently venture to the outdoor classroom because that is the best place to study the homes of God’s creatures and the harmonious balance and sometimes imbalance of the creation. A proper understanding of the outdoor creation requires the learner to live in that outdoor environment. By careful observation of nature and an intimate knowledge of the habitats and characteristics of creatures a student will more fully understand Job 12:7-9, “But ask now the beasts, and they shall teach thee; and the fowls of the air, and they shall tell thee: or speak to the earth, and it shall teach thee; and the fishes of the sea shall declare unto thee. Who knoweth not in all these that the hand of the LORD hath wrought this?” That knowledge is of great value to God’s children.

Why Study Streams?

Gary VanDerSchaaf

Having seen that out-of-door activities are a must for science classes of all levels, one might ask, “Why study streams?” Why not beaches or sand dunes, fields or forests, marshes or bogs, or any other of the many ecosystems in God’s creation?

One of the overriding criteria for this session of the science workshop was to produce a unit that Protestant Reformed science teachers — teachers who may have little or no formal science training, knowledge, or even enthusiasm for the same — would actually use. Therefore, the unit must have the broadest possible appeal and application. Not everyone is near a fresh or salt-water shore. Iowa has a dearth of coniferous forests, and there are no alpine ecosystems near Grand Rapids. Furthermore, not all science teachers relish the idea of leading a class of third graders into the muck of a swamp, or of herding a class of seventh graders into the boats necessary for the study of a pond or lake.

A stream, however, has none of these practical disadvantages. Everyone is near (“near” in the field-trip sense of the word) a stream, and most people are close to many. And streams come in such a variety: if tramping through thick underbrush alongside a “wild, untamed” stream is not your idea of a good time, any worthwhile public park has a brook or stream running through it. Even if you are not an outdoors, hands-on individual, an on-site study of a stream should pose no serious threat to your psychological or pedagogical equilibrium.

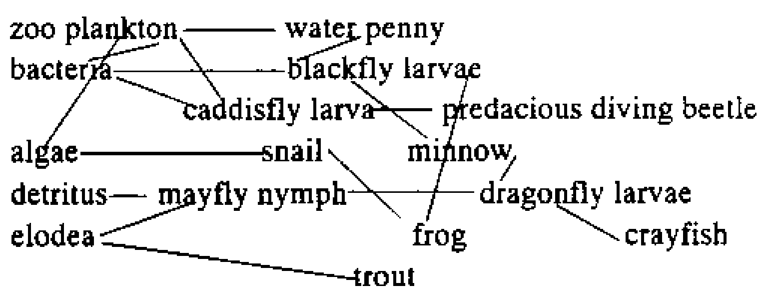
Another advantageous factor is student experience and motivation. As with teachers, so with students; everyone has access to and experience with streams. I have taught units on desert life to students who have never been west of Lake Michigan, and units on mountain communities to students whose idea of a big hill is limited by the highest roller coaster at Cedar Point, but every student "knows about" streams, and will have access to them throughout his life. Furthermore, streams provide students a chance to "mess around in," and learn in, that incredibly fun stuff — water — in a comparatively safe and controllable environment.

In addition to these practical advantages-accessibility, variety, motivation, lifelong application-stream study offers unparalleled education opportunities. Let us consider some of the basic ecological concepts that can be taught through stream study.

Perhaps the fundamental ecological concept is that of the inter-relatedness of all living things with the environment. The interaction of biotic (living) things with abiotic (non-living) factors that forms the heart of ecological study can be amply demonstrated to students of all levels in terms and details appropriate to those levels. For instance, what material composes the stream bed? Sand and silt? Gravel? Bedrock? In turn, how is the life found in the stream suited to the type of bed? Do you expect to find burrowing insect larvae in bedrock streams? Will you find dragonfly larvae, whose life cycle depends on emergent plants, in streams whose beds cannot support such plants? Will water pennies be found where there are no rocks to cling to? Why do not caddis fly larvae build their houses upon sand or mud?

Other abiotic factors such as temperature, dissolved oxygen (D.O.), and rate of flow, all exert a powerful influence on the quantity and type of life found in the stream. And most streams show a remarkable range within these factors. That is, one stream can be used to show how different combinations of the same abiotic factors within one ecosystem can form markedly different communities of plants and animals. The teacher can then assign different groups to different parts of the same stream, one group studying a riffle, another a slowly moving, shady stretch, another a swiftly moving portion, still another group studying a nearly stagnant pool, and so on.

Other basic ecological concepts can be demonstrated as well. The youngest students can be shown elementary food chains in class: plant → insect larvae → fish and try to collect specimens of each trophic (feeding) level. Older students should study, collect, and identify more detailed chains: algae → water penny → dragonfly larvae → crayfish, with instruction culminating in the construction of a food web:



A study of streams provides the Protestant Reformed teacher an excellent opportunity to teach more than scientific principles. The study of a polluted stream, while perhaps not aesthetically rewarding, is a worthwhile project. Such a study will surely go beyond dissolved oxygen and mineral test, flora and fauna identification, and while it will include a discussion of the types and sources of pollution (thermal, chemical, sedimentary; urban, rural) it will not end there. A study of stream ecology must include a discussion of, and outdoor activities designed to demonstrate, the effects of man's sinful waste and destruction of water resources, as well as discussions and activities that promote concepts of resource stewardship.

This type of instruction need not be a moralistic tag-on at the beginning or end of the unit. After the teacher has made clear the place of streams in the earth's great hydro logical cycle, the student must see that whatever affects the seemingly insignificant stream will in turn affect all other parts of that cycle. Students must know that the water cycle is one of the means God uses to sustain life, that it is an exceedingly fragile cycle, knowing that as Americans they use and pollute, in one form or another, over 1,000 gallons of water a day (three times as much as the average European), knowing that 75% of the earth has no fresh water supply, knowing that we are rapidly diminishing and destroying our own available fresh water. If we are to sing, "He waters the hills with rain from the sky," we must sing it with the knowledge that this rain in many places on earth, is poisonous, that huge tracts of land (Germany's fabled Black Forest, for example) are being destroyed by it, that over 80% of the lakes in the American Northeast have been made wormwood, bitter, acidic, and lifeless.

It may seem a large and grandiose step from your nearby park stream to the global concern of acid rain, but the truth of the inter-relatedness of creation, a truth revealed by the study of that very stream, reveals that such a step is not so far-fetched. The scientific principles which apply to that innocuous little stream are the same that govern mighty rivers and vast oceans, and the principles of responsible stewardship apply not only to the backyard creek or nearby stream, but to the entire creation over which we, created in God's own image, have been placed.

Chapter 2

What?

What to Study?

Gary Lanning

The speed at which a stream flows can have a profound effect upon the ecology of the stream. It plays a large part in determining what flora and fauna can exist in a particular stream. A slow-moving stream may be home to many forms of plankton whereas a stream with a rapid current usually sustains far fewer truly planktonic fauna. Slow-moving streams tend to have beds composed of silt or mud while rapidly moving streams have gravel and sand beds for much of their length. Therefore the benthic organisms found in these two types of streams vary widely as those organisms which can survive in gravel beds likely cannot survive in mud bottoms, due largely to the fact that their respiratory structures would get clogged up with silt. Thus different parts of the same stream may support vastly different bottom dwelling fauna. An investigator should therefore sample a stream at various sites which have obviously different current speeds. These sites could include pools, riffles, and straight runs.

Many people assume that the fastest part of the current is at the bottom of the stream. It has been found that the highest rate of flow is actually at 0.6 of the depth, due to bank drag and surface tension drag on surface of the stream (13mm). It has also been shown that a very thin boundary layer occurs at the surface of submerged rocks and stones and other solid bed features. The current speed is often zero in this boundary layer. Thus many bottom dwelling organisms have a flattened body shape, not so that they can withstand great forces caused by water rushing over them, but rather so that they can flatten themselves against rocks, thereby getting into the boundary layer where there is no current.

The current speed of any stream rarely exceeds 300 cm/sec. because at speeds greater than 200 cm/sec. bank erosion occurs, thereby enlarging the bed and consequently maintaining or lowering the current speed.

In any ecosystem, not only is the number of individual organisms present important, but so is the number of different kinds of organisms. The greater the diversity of organ isms the more stable is the ecosystem. To understand this, one must understand the concept of food chains, or more accurately food webs. Using the food-chain idea a producer (green plant) is eaten by an herbivore (grasshopper), which is eaten by a first-order carnivore (preying mantis), which is eaten by a second order carnivore (snake), which is eaten by a third order carnivore (raccoon), etc.

In any ecosystem many of these chains can be drawn, using the organisms which live there. The ecosystem is stable when a variety of organisms can be inserted at each link of the chain. Suppose that in a given ecosystem grasshoppers were the only herbivores. If the seasons' new crop of grasshoppers were destroyed by frost, disease, etc., then the entire food chain would break down. But if there existed another herbivore species which survived (perhaps due to different timing of its hatch) then the first order carnivore would have an alternate food source and the chain would still be intact. Thus we look for diversity whenever we study ecosystems. The diversity problem can occur at any level in the food chain including the producer level. This has recently been seen in the Great Lakes states. Along many streams and wetland areas can be seen large areas of a beautiful purple flower known as purple loosetrife (Lythrum salicaria). This plant, although pretty, is very aggressive and has completely taken over many areas, excluding any other plant species, thus creating an unstable ecosystem. At least one state has undertaken the monumental task of eradicating this plant.

We hear much talk today about toxic chemicals polluting our waterways. We are warned not to eat fish caught in certain bodies of water even though we may swim in the same water. This seeming paradox can also be explained by an understanding of the food chain concept. Toxic chemicals may be present in a body of water in minute amounts, amounts which we need not worry about when we swallow an occasional mouthful while swimming. Some small organisms (bacteria) use the dissolved substances in water as a source of energy. The toxic chemicals are also absorbed and remain in the bacteria which accumulates in them. The bacteria in turn is eaten by an organism in the next trophic level (protozoan) which accumulates all the toxic chemicals from all the bacteria which it ate. This is repeated at each trophic level until the top carnivore (salmon, trout) has accumulated many times the safe level of toxic chemicals in its flesh. This biomagnification occurs due to the property of some toxic chemicals to accumulate in the tissues of organisms. Now the stage is set for man to catch and eat the fish which has many toxic chemicals in its flesh. Thus the government warnings limit the number (or pounds) of fish eaten per year from certain bodies of water.

VOLUME OF FLOW (DISCHARGE)

Volume of flow or discharge refers to the amount of water which passes a certain point in a specified period of time. While not as important to the ecology of a stream as rate of flow, it nevertheless can affect the organisms living in a stream, especially if the volume changes drastically. This happens during flooding. Many organisms are harmed by this occurrence. Fish and fish eggs may die or be left stranded after flood waters recede. On the other hand, some species of fish depend on flooding or a rise in discharge levels to begin breeding.

DISSOLVED OXYGEN

Dissolved oxygen is one of the most significant chemical substances in water. It regulates life activities and indicates the condition of the water. It is essential for respiration of all creatures (with the exception of some anaerobic organisms) and is needed by decomposer organisms (bacteria, protozoans). Dissolved oxygen (D.O.) is not the O in H20. Rather it is oxygen which has been dissolved, i.e., oxygen which exists between the molecules of H2O. Most aquatic organisms have structures (e.g., gills) for using this oxygen rather than using atmospheric oxygen as mammals and humans do.

The amount of oxygen which can be dissolved in a body of water is limited by three factors:

1. temperature.
2. salinity.
3. partial pressure of oxygen in atmosphere.

When studying fresh water environments, temperature is the factor which is most likely to limit the amount of D.O. in a body of water. (This is true for relatively clean streams. Polluted water can cause a sharp drop in D.O. as we shall soon see.)

As the temperature increases, the amount of oxygen which can be dissolved in a volume of water decreases. This is opposite of that with which we are most familiar. If we want to dissolve a lot of sugar or salt in a volume of water, we heat the water. With dissolved gases, however, the opposite is true. Thus temperature readings are a necessary part of any stream investigation.

Two sources supply virtually all the D.O. to a body of water:

1. photosynthesis.
2. atmosphere.

In a stream with very little plant and algae life, the atmosphere contributes far more oxygen than does photosynthesis. However, in quiet pools rich in plant life, the opposite may be true, depending on what volume of water in the pool is exchanged with fresh oxygenated water coming from upstream.

Streams depend on turbulence for the dissolving of oxygen into the water. Simple diffusion of oxygen from the atmosphere to the water through a quiet air/water interface occurs at a very slow rate. It has been found that to raise the oxygen concentration by 0.4mg/L at a depth of 10 meters by simple diffusion would take 600 years. Thus riffles, falls, cataracts, and other surface disturbances are essential for high levels of D.O. Therefore the rougher the bed, the more stable the D.O. environment. It seems, however, that most streams have ample disturbances as most clean streams are usually 100% saturated with oxygen.

Several exceptions to the above statement occur:

1. water near a spring.
2. streams completely covered with ice for long periods.
3. stagnant pools after autumn leaves drop in nearly dry streams.
4. polluted streams.

Ground water which emerges near a spring is often devoid of D.O. due to its lack of contact with oxygen underground. This is, however, of little ecological consequence as the cold spring water quickly picks up oxygen from the air.

If a stream is completely covered with ice for a long time and distance, the D.O. levels could drop. Usually this does not occur because often there are breaks in the ice cover. Also, the water level tends to drop when the volume decreases as the winter progresses, thus forming a layer of air between the ice and the surface of the water.

When leaves and plant material drop into the water, they are used as a food source by many organisms including insect larvae, protozoans, and bacteria. These detritus feeders and decomposers may then multiply rapidly in the abundant food supply. Those organisms use oxygen much as we do and could deplete the D.O. in a pool if the stream has nearly dried up and is not supplying the pools with new oxygenated water. This also is of limited ecological importance as organisms which live in this kind of stream likely have life cycles which protect them from adverse environmental conditions (e.g., periods of dormancy).

Much the same event occurs in polluted water, although now with ecological catastrophe possible. When pollutants, such as nitrates and phosphates from agricultural run-off or organic matter from sewage discharge, enter a stream they create a high demand for oxygen. Nitrates and phosphates cause a sharp increase in the plant and algae growth of a stream (when these plants die they are decomposed by micro-organisms which use oxygen for respiration). If enough plants die, there will be a large oxygen demand and thus the D.O. concentration can be reduced to the point at which organisms (fish, insects) can no longer survive. Likewise organic waste from sewage discharge decomposes and imposes a high oxygen demand on the ecosystem.

TEMPERATURE

Temperature affects both the physical environment and the biotic community in an ecosystem. As we have seen, temperature determines the amount of oxygen that can be dissolved in a volume of water. This, of course, plays a part in determining what organisms can live in a given stream.

Most species of living organisms have a definite temperature range in which they can exist. If the temperature rises above or falls below that range, then the organism will not thrive and reproduce and may move out of the area if possible. If the temperature becomes extreme, the organism will die. Thus we find different species of insects and fish in streams of higher latitude than we find at lower latitudes. Also we may find different organisms living near the source of a spring-fed stream than are found near the mouth of that stream if the water has warmed up as it progressed downstream.

This temperature dependency which the stream biota exhibit has some implications for man as he alters natural environments. Clear-cutting forests along streams eliminates shade and can raise the mean temperature of the stream.

Dams create many ecological problems, some of which are temperature related. The impounded water is no longer flowing and has much time to be warmed by the sun and thus may be warmer than the mean temperature of the stream. If the water which is released from the dam is taken from the top layer of the impoundment it could also raise the temperature of the stream for a considerable distance downstream from the dam. If, however, the water is released from the deepest part of the impoundment, this water could be colder than the mean temperature of the stream and thus cool the stream for a distance downstream. An accompanying change in flora and fauna would likely be seen in such a stream.

pH

pH is a measure of the hydrogen ion content present in a substance. It is used to determine whether a substance is acid ($pH < 7$), neutral ($pH=7$), or alkaline ($pH > 7$).

Most natural waters have a pH value from 5.0-8.5. Pollutants can cause the pH to move below or above this range. Acid rain, or probably acid snow, can lower the pH of a body of water. This is most noticeable in the spring when the snow melts, dumping a load of acidic water (pH=4, 5) into the stream. Most aquatic organisms are very sensitive to changes in pH.

BED

As has been stated before, the type of bed which is found in a stream is dependent on local geology and on current speed. The type of bed in turn, at least in part, determines the flora and fauna of a stream.

Basically four types of bed could be encountered: bedrock, gravel, sand, silt, or mud. Silt or mud settles out if stream velocity is at or below 20cm/sec. At a current speed of 20-40cm/sec. a sand bottom often occurs. However, large stones can slow current and therefore sand and gravel can often be found among large stones.

Siltation of streams is a problem which can have a detrimental effect on the flora and fauna of a stream. Construction projects near streams almost always cause some erosion and subsequent siltation. Pastures which allow cattle to enter a stream can cause severe bank erosion and siltation. Cleared land often results in sheet erosion. Elimination of swamps and marshes causes increased run-off of eroded material directly into a stream. Some of the effects of this siltation are very gradual and therefore not easy to monitor. Therefore, it would be of value to investigate a wooded area of a stream and compare it to one of the areas listed above.

In gravel-bottomed streams some organisms (e.g., insect larvae) live in the gravel itself to a depth of approximately 10 cm. Other organisms can be found at the water's edge along shady reaches where the sand is wet but not covered with water. At this line, evaporation apparently causes enough water movement through the sand to supply organisms with oxygen and nutrients.

Riffles can occur in streams where rocks and pebbles of various sizes have collected. These large stones are always found closer to the surface, presumably for the same reason that the larger caramel corn is always found above the smaller peanuts in a box of Cracker Jacks. Riffles do not migrate, although individual stones may migrate from one riffle to the next riffle downstream.

BIOTA

The biota of a stream includes all living organisms. An investigator is likely to find many types of insect larvae and nymphs. If plankton nets are used, diatoms, protozoans, and small crustaceans can be collected. Muscles, worms, hydras, amphipods, and other crustaceans are also often found in fresh-water streams.

Although somewhat difficult to identify and classify, the algae can be a good indicator of a stream's purity. If compound microscopes are available, students should be encouraged to look for a variety of different types of diatoms. Their beautiful symmetry makes them worth looking for. The green and blue-green algae are also worth observing with a microscope, if for no other reason than to observe the detail and structure of something which most students think of as being slimy and disgusting. A higher appreciation can be gained for this important producer by examining the fine detail of individual cells and colonies.

Most of the excitement will probably come from discovering many nasty-looking insect larvae and nymphs. A great number of those may be found exhibiting many different shapes, sizes, and structures. Following are some hints to help interpret what you find.

One of the most common body shapes you will likely encounter is the flattened shape. As stated earlier, this allows some organisms to remain within the boundary layer and thus exist in rapid streams. A flattened body plan also allows organisms to crawl under rocks and into narrow crevices both to avoid predation and to avoid strong currents.

Some stonefly and mayfly nymphs are not flattened but rather have streamlined bodies similar to the body shape of a fish. This is the shape most resistant to fluids. Many of these nymphs have long tails which they use like windvanes to keep them pointed upstream, into the current.

Water pennies and other invertebrates have movable spines which can be fit to the contours of the substratum they are sitting on, thus preventing the current from getting under their bodies and lifting them up.

Some fly larvae have suckers which allow them to exist in moving water.

Many caddis worms and other aquatic larvae use silk and sticky secretions to capture food and to attach themselves to substratum. Cased caddis worms use this device too when they molt, because they cannot use their claws at this time.

Simulian (blackfly) larvae produce silk from their salivary glands making a tangled mat on the substratum. They then use hooks to attach themselves to this mat. They often include a silk safety-line in case the larva becomes dislodged.

Many aquatic insects fly very poorly if at all. Some which may fly well only live a few hours as adults. This all may serve the purpose of keeping the insect near to the body of water from which it emerged and to which its offspring must be returned for survival. It could be difficult for an insect successfully to find another watercourse if it flew very far from home.

Sometimes one can observe a submerged insect larva or adult which has an air bubble attached to its posterior end. The insect uses this air to breathe. As the oxygen in the bubble is used up, it is replaced by dissolved oxygen from the water. This occurs as long as nitrogen gas remains in the bubble, thus the bubble lasts a long time. A practical note concerning aquatic insect larvae and nymphs and their need for oxygen: it is better to transport live invertebrates back to the lab in wet moss than in a vial of water. As the temperature rises in the vial, the D.O. concentration decreases to the point at which the organisms die. When transported in moss, the organism can often take oxygen directly from the atmosphere.

Most insect nymphs and larvae have a variety of hairs and bristles somewhere on their anatomy. These are used to capture food as well as to help them maintain their position on the substratum.

An investigator who samples a stream during different seasons of the year will notice changes in the fauna. Following are some generalizations concerning the changes which can be expected:

—AUTUMN: generally maximum numbers and biomass — many species hatch during autumn and grow during winter.

—WINTER: hatching slows, so numbers may decline, although biomass may remain constant due to increase in body size of those which grow in winter.

—EARLY SPRING: loss in numbers and biomass due to emergence of early stoneflies.

—LATE SPRING: sharp drop in biomass as many species emerge.

—SUMMER: biomass generally increases and numbers depend on local fauna — if scuds are dominant the numbers increase as these produce many broods per summer — but if insects dominate, then numbers may fall off as hatching of eggs declines in heat of summer.

Materials

Gary VanDerSchaaf

Most equipment for a stream study is available in the home or already hiding somewhere in your school. Below is listed the basic equipment you will need. Prices are given for items you may wish to buy; a list of supply companies is included in the bibliography of this unit.

I. Material you may want or have to purchase:

A. Collecting nets ($9-$30 — specify fine mesh).
B. Thermometers ($2-$9).
C. Insect/plant i.d. keys ($5-$20).
D. Hach D.O. kit ($25).
E. Complete water test kit — includes “D” above ($60).

II. Material from home or school:

A. Baby food jars, pill bottles, film containers for samples.
B. Plastic or metal trays, preferably white, to scoop, sift, and examine specimens.
C. Waterproof markers.
D. Strainers.
E. Timers — stopwatches, those ridiculously complex wristwatches the kids wear which allow them to compute what time it is and how fast they are swimming, underwater, through seven time-zones.
F. Meter stick and reel tape measure.
G. Notebook.
H. Orange (for rate of flow).

III. Survival Equipment:

A. Insect repellent.
B. Extra socks and shoes.
C. First-aid kit

Chapter 3

How?

On-site Pre-trip Preparation

Dave Harbach

Finding a suitable site to study stream ecology is not a matter of looking on a map to find the closest stream. Were that the case, how simple it would be if we all had a stream near school. But, although a stream nearby is handy, it may be that that particular stream is not suitable for study. What then are the factors that you need to consider when looking for a stream that will be worthwhile to study?

The first factor is accessibility by car or bus. What we need here is to get as close to the stream as possible so that there is a short walking distance to reach the study site. Remember, you are carrying equipment with you: nets, buckets, etc. The less time it takes to reach the site and to begin working, the more enjoyable it is for your students.

The second factor for stream study is the condition of the environment while walking to the stream. Even a short walk in dense undergrowth can be discouraging. Who wants to hack their way through thorns, high bushes, and poison ivy, or crawl under or over fallen trees, or slosh through marshland to reach the stream, tired and exhausted? Avoid paths that lead you up or down hundred-foot banks or steep hills. Because of the equipment you must carry, and for safety reasons, it is preferable to choose a stream that is within a short walking distance along a well-marked path.

Stream environment is the third and perhaps most important factor. Visiting the stream site ahead of time is a prerequisite to a successful learning experience. You will want to locate several places along the stream that have different streambed conditions. Look for the following stream characteristics: a sandy stream bed, a gravel or rocky stream bed, riffles, falls, a place where a tree has fallen into the stream, side pools of stagnant water (great for the study of algae), and boulders that divert stream flow. If possible, locate also the headwaters of a stream or a place where springs flow into the stream.

For some of us the stream running through the nearby park will have most of the characteristics mentioned above and will be perfect for study by lower elementary children. For other teachers it may require getting permission to trespass across land to the stream site. Even a ditch that has continuous flowing water in it can provide a variety of characteristics. Whatever places you choose, the more variety of characteristics it has, the better it will be for studying stream ecology.

A note of caution! In our day there are many polluted streams. Care should be taken to determine if a stream is so polluted that the health of the students and yourself might be jeopardized. I know in the Grand Rapids area there are times after a heavy rain that the Grand River is so polluted by sewage that warnings are put out not to come into contact with the water. If you do discover a polluted stream, you might even consider contacting the Department of Natural Resources in your area to make them aware of the pollution.

A word of advice. Duplicate footwear is a must. Standing in soggy shoes and socks is not the best way for you and your students to spend your school day. You should expect your footwear to get wet and muddy as you walk through streams to study their various characteristics. Also take along insect repellent. Muskol insect repellent and Skin So Soft from Avon are two very good products for keeping the biting critters off your body. Skin So Soft is not advertised as an insect repellent, but the rumor is that whatever is in the product does an excellent job of repelling mosquitoes. Be careful about applying to exposed skin any insect repellent that contains 100% deet. It has been reported that deet applied to skin may cause children to experience harmful effects. It is alright to apply deet to clothing without harmful effects.

In-class Pre-trip Preparation

Dave Harbach

In order to provide a cohesive unit to use in the classroom, I have included vocabulary pages to help your children learn the terms used in stream ecology, data sheets for stream study, graphs, and pre-trip, post-trip pages for each of the aspects of stream ecology that can be investigated by your students. In addition, there is a copy of the Common Water Insects page from Our Living World by Daryl Vriesenga, Instructional Fair, Inc., Grand Rapids, and figure 105 on page 199 of Ecology and Field Biology by Robert L. Smith, Harper & Row, New York (see Appendix B). Even if you prepare the students in advance to study all of the aspects, two hours at the stream will give you enough time to study only one site. For this reason, those of you in the lower elementary grades may wish to study only a few of the aspects of stream ecology. My suggestion is that, to do a bare-bones study, you make sure to investigate temperature of the water, rate of flow, site characteristics, biotic life, and, if at all possible, dissolved oxygen (D.O.). Dissolved oxygen is one of the most important factors in maintaining biotic life in the stream. For a more in-depth study of these characteristics and other possible activities, read my colleagues' sections on stream ecology.

SPECIAL PEOPLE

Assign the following jobs to group members: data recorder, depth and distance measurers, time reader, thermometer reader, pH reader, equipment handlers, dissolved oxygen helper, water sampler, and insect collectors (all). Vary the jobs of group members at each site. Members of each group will need to do more than one job and will need to help others at a site. Depth and distance measurers will need to work with the time reader. The data recorder will write down all information on the data sheet.

VOCABULARY

The following terms are used frequently in stream ecology. Many of the meanings of these words you will need to learn before you go to study a stream. The terms should be used while investigating stream life. The terms are not necessary in the lower grades, although children may find it stimulating to learn them.

Biota — the plant and animal life of a specific area.

Flora — the plants that live in a specific place.

Fauna — the animals that live in a specific place.

Plankton — microscopic (you need a microscope to see them) animal and plant life floating or drifting in a body of water. Plankton is food for fish. Zooplankton is the animal life floating in water that fish eat as food.

Algae — green plants that live in water.

Organism — any living thing.
Larva — an insect in its early stages of growing into an adult insect.
Ecosystem — the interaction of biotic (living) and abiotic (non-living) factors in the same area.
Food chain (web) — network of animals that feed on plants and each other in order to live.
Benthic organisms — organisms that live in the bottom ooze of streams, lakes, or ponds.
Producers — a green plant in a food chain.
Herbivore — plant-eating organism.
Consumers — plant or animal-eating organism.
Biotic index — a measure of the number of different kinds of organisms living in a stream which also indicates the health of the stream. The greater the different kinds of organisms in the stream the healthier the stream.
Stream bed — bottom of a stream.
Riffle — a rocky area or obstruction in a stream producing a ripple or rapid choppy water.
Current — a body of water flowing in a certain or definite direction.
Rate of flow — current speed or velocity (L/t = distance/time = cm/sec). A fast ROF will produce a gravel stream bottom whereas a low ROF will produce a silty stream bottom.
Volume of flow — amount of water flowing downstream (volume = width of stream x average depth of stream x rate of flow).
Dissolved oxygen (D.O.) — the amount of oxygen between molecules of water.
pH — hydrogen ions in water (a reading less than 7 is acidic, 7 is neutral, and more than 7 is basic or alkaline).

KNOW YOUR WORDS

Fill in the missing words with the words at the bottom of this section. Each blank line is a letter of the missing word or words. (See Appendix A)

1. The amount of silt on a stream bottom changes when the _ _ _ _ of flow changes.
2. A stream shaded by trees has a lower water _ _ _ _ _ _ _ _ _ _ _ than the same stream without trees.
3. The constant churning of stream water over _ _ _ _ _ _ _ and falls increases the oxygen content of the water.
4. The higher the _ _, the more abundant is the aquatic life.
5. The riffle is an ideal site for the production of blue-green and green _ _ _ _ _.
6. A stream that has many riffles to churn the water will have a high _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ content.
7. A stream _ _ _ with lots of sand is a sandy bottom stream.
8. The bottom ooze of a stream has many _ _ _ _ _ _ _ organisms.
9. The area of the interaction of biotic and abiotic factors is called an
10. The _ _ _ _ _ of a stream are the plants and animals that live in the stream.
11. A _ _ _ _ _ _ _ _ _ is the network of animals feeding on one another.

12. You need a microscope to see the _ _ _ _ _ _ _ _ _ that fish eat.

WORD BANK

biota rate bed temperature food chain pH algae benthic plankton dissolved oxygen riffle ecosystem

In-class Pre-trip Preparation

Gary VanDerSchaaf

Before you take your class to the stream, your students must know exactly what they are to do, how to do it, and where. Your students will know "what, how, and where" only if you have made adequate on-site and classroom preparation.

You must visit the stream first, by yourself, before going with your class. You should have in mind the following kinds of practical questions when making this visit:

1. Is this stream accessible? Can we drive close to it, or will we have to walk a ways? Are there trails to the stream, or will we have to play "jungle safari"?
2. Does this stream possess a sufficient variety of characteristics and communities? Does it have a variety of bed-types? Swift and slow portions? Shady and sunny stretches? Pools and riffles? And again, are these areas accessible?
3. Look out for hazards; poison ivy along trails or streams, deep water.

Once you have chosen your stream, collect samples of stream life, plant and animal, to show your students as part of your preparation. You may also want to take water temperatures, pH readings, rate of flow measurements, perhaps even perform a dissolved oxygen test (on-site or back in the classroom, as a demonstration of how-to), just so that you have some figures to present to the class as to what to expect. With the knowledge of the area and samples collected on your own pre-trip outing, you are ready to begin classroom preparation.

Students must know how to manage the data and sample gathering equipment. With the exception of the D.O. kit, there are no complicated instruments or procedures involved. Still, you will want to show students how to take a temperature reading (and how to read a thermometer). The same holds true for pH testing. (In his own field work for this unit, this writer raised great alarm among his colleagues by announcing the stream pH to be 13, basic enough to strip paint and dissolve some plastics. Further investigation revealed that I had been testing not the stream, but the insect repellent smeared on my hands.)

You cannot overemphasize proper recording procedures. Samples must be labeled — where taken, and if known, what -on-site. The same information, along with any other data — pH, temperature, rate of flow — must be recorded in notebooks or data sheets, again on-site. You will wish to prepare data sheets for all the information you want to collect. Review these sheets prior to the trip so students know what information goes where.

Students must also know who goes where, and who will be doing what when you are there. It is best to divide the class into groups of two students each, three students at most. Each team should be assigned a specific stream portion, each team member should be assigned specific on-site tasks. You must make sure that each student knows what he has to do and how to do it before you reach the stream.

Finally, when you are on-site, personally escort each group to its predetermined area. Once all groups are established and working, revisit each group to check progress and answer questions. Be sure to have students include in their data a description of the area they are working in: stream bed-type, deep or shallow stream, shaded or sunny area, etc. Unless you have a very small class, or are studying an incredibly diverse stream, you will have more than one group in a specific community; therefore, maintain discipline. Students unused to working field trips will see this as just a day-off from school unless you take (and give?) pains to convince them otherwise. Remember, planned, specific, and supervised tasks reduce the tomfoolery that discourages teachers from attempting field trips. *Semper Paratus*.

Procedures for Determining Various Characteristics of Streams

Gary Lanning

RATE OF FLOW

Whenever you sample for benthic organisms and D. 0. you should also calculate the rate of flow. Rate of flow or current speed can be determined easily using a tape measure, stopwatch, and orange. Pick two points along the stream and record the distance between them. The length which you choose is not important. What is important is that the length is homogeneous, that is, all riffle or all smooth, straight run, etc. Place an orange in the current at the upstream point and using a stopwatch determine the amount of time it takes for the orange to reach the point which you choose. Rate of flow = L/t where L = length of stream section over which the orange traveled, and t = time needed for the orange to travel. This should be repeated three times and an average taken for any section chosen. Also, it is best when measuring current speed around a bend, to measure the current along both the outside and the inside of the bend as these measurements will differ markedly. Even on straight sections you will get the most accurate results if you divide the stream into three parts, each part comprising one-third the width of the stream section you are studying. The average of these three readings should then be recorded as the rate of flow for that section of the stream.

If the orange does not get snagged or slowed down by hitting the bottom this is a fairly accurate method of determining current speed.

VOLUME OF FLOW (DISCHARGE)

D = wdat/L

D = discharge
w = width of stream
d = mean depth
L = distance over which float (orange) travels
t = time float traveled
a = 0.8 if bed is rough
= 0.9 if bed is smooth

Again, the best results are obtained when the stream section is divided into three widths and an average volume recorded.

DISSOLVED OXYGEN

Testing for dissolved oxygen requires some special equipment but if at all possible should not be left out of a stream survey. The test itself is very easy if students have access to a D.O. test kit (available from Hach Chemical Co., Loveland, Colorado [1-800-227-4224] or LaMotte Chemical Co., P.O. Box 329 Chestertown, MD 21620 [301-7783100]). These kits cost approximately $40 and contain enough materials for about 100 tests.

For those teachers who want to teach some chemistry at the same time, you might prefer to use the method explained in *Standard Methods for the Examination of Water and Wastewater* and many other lab manuals. The chemistry involved in this and other water tests (hardness, alkalinity, etc.) can be found in the free publication from Hach Chemical Co. entitled *Chemical Procedures Explained*.

After the amount of dissolved oxygen is determined (usually in mg/L which is equal to parts per million) one can find the 0/0 saturation of the water by using the accompanying (see appendix B) nomogram. Cool stream water is usually near 100% saturation.

Because D.O. and other tests are influenced by the current weather conditions (air temperature, cloud cover, and precipitation), those of the previous 24 hours should always be recorded.

TEMPERATURE

The temperature of a stream is a very important characteristic as it directly influences D.O. content, types of organisms, etc. Yet because temperatures can vary from place to place in a stream (shade, open sun, proximity to spring, day/night) a temperature reading from a single site is of limited value. However, the temperature must always be taken at the site where a D.O. determination is made. At the very least, temperature readings should be taken at several sites. A better way to get an idea of the true temperature of a stream is to place a maximum/minimum thermometer in the stream and average the maximum and minimum temperatures daily or weekly. This thermometer can be protected by placing it inside a drain tile and submerging it in the stream.

pH

pH can easily be determined by using pH paper available from many science supply houses. A digital pocketsized meter is also available for $30.00 from Cole-Parmer Instrument Co. (1-800-323-4340).

If using pH paper, be careful not to touch the end of the paper which will be used to determine the pH of the water sample. Body oils, insect repellent, etc. can drastically influence the test.

BIOTA

Various methods can be used to determine the kind of plants and animals which occur in and around a stream. The method used will depend on the instructor’s goals. Much qualitative data can be obtained simply by observing the amount of vegetation growing in the stream and on the banks. If desired, this vegetation can be identified. Furthermore, quadrat studies can be made to determine dominant species, etc. These, however, are advanced techniques and, although not difficult to perform, they do require an advanced understanding of ecological relationships.

Most teachers will want to sample the invertebrates which live in the stream. Those can be divided into two groups: plankton, and benthic organisms.

The plankton consists of those organisms which travel about suspended in the water. Those include diatoms and other unicellular algae, protozoans, and possibly some very small animals.

Plankton can best be collected by means of a plankton net which is towed through the stream. These nets are fairly expensive (about $30.00) due to the small mesh size which is necessary to capture plankton. An alternate method is simply to fill a collecting bottle with water. If this bottle is allowed to stand undisturbed for a period of time, much of the plankton will settle to the bottom where they can be collected with eye droppers. This method does not give as satisfactory results as the net method. Regardless of the method used to collect plankton, a compound microscope is essential for observing the planktonic organisms.

Collecting and observing benthic (bottom dwelling) organisms is easier and probably more exciting than collecting plankton. Benthic organisms consist primarily of insect larvae and nymphs. Also found are various crustaceans and mollusks. All that is needed is a shovel and net. Long-handled stream nets are available commercially, but again they are quite expensive. Large aquarium nets or kitchen strainers of various shapes and sizes are quite adequate. To collect bottom dwellers, simply hold the net in the stream and cause a bottom disturbance immediately upstream. This can be done with the shovel or with one's feet. The benthic organisms are swept downstream and into the net. The net should then be emptied into a shallow pan (preferably white) where the organisms can be identified.

If a stream is going to be monitored repeatedly it is best to make a reference collection of invertebrates by preserving one of each kind in a jar of alcohol. This collection can be taken to the stream and used to identify specimens collected on subsequent outings. In this way a class does not deplete the population by repeatedly taking specimens back to the classroom.

All benthic organisms are not easily dislodged. Larger stones, therefore, should be examined for attached fauna. Also submerged branches should be examined *in situ* for hydras which are easily overlooked.

BIOTIC INDEX

The biotic index is a measure of the number of different kinds of organisms that live in a stream and is an indicator of the health of a stream. It is based on the principle that the more different types of organisms a stream has, the healthier it is.

The biotic index we use is based on the one developed by Ralph D. Scott in 1969. It is a simple method because you need to identify only the organism's order or class and not its genus and species.

The system divides organisms into three groups or classes. Class I organisms are very sensitive to environmental change and are found in fast-flowing water with rock or gravel bottoms. These organisms require a lot of oxygen. Examples are caddisflies, mayflies, stoneflies, and water pennies.

Class II organisms are not as sensitive to environmental change and can be found where some degree of aging (eutrophication) of a stream is occurring. Examples of Class II organisms are damselflies, dragonflies, crayfish, blackflies, craneflies, or flatworms.

Class III organisms are very tolerant of a high eutrophic or polluted state. Examples are leeches, midges, mosquitoes, air-breathing snails, and tubifix worms.

To calculate the biotic index, use the following formula:

2X (number of different Class I organisms) + the number of different Class II organisms.

Class III organisms are given a value of 0. The higher the biotic index, the healthier the stream. According to Scott (1969), a biotic index of 10 to 15 indicates a healthy stream. A biotic index of 0 indicates a highly eutrophic or polluted stream. (See Appendix B)

SUGGESTED INVESTIGATIONS FOR THE HIGH SCHOOL

— take D.O. readings in a still pool after autumn leaf fall. Collect organisms and look up life histories to determine how they can survive periods of low oxygen.

— compare D.O. before and after a rainstorm. If turbidity increases from the storm, the D.O. may drop due to drop in photosynthesis (only in still waters with much plant growth).

— compare D.O. above and below wastewater treatment plant discharge.

— in streams with heavy plant growth, determine at what time of day D.O. is highest and lowest.

— determine the dominant genus of diatom present at different seasons.

— determine whether diatom species are different on upstream and downstream side of rocks.

— check for abundance of plankton in dead-water sidearms as opposed to flowing stream.

— look for structures which make contact with substratum to hold organism in place, e.g., gills. Some species of genus Rhithrogena (mayfly) have inturned gills which prevent water flowing in under and also provide more friction.

— try agitating Rhithrogena and other mayfly species which lack inturned gills. Rhithrogena should be last to be dislodged.

— look for hooks and grapples on insect larvae and nymphs (genus Corydalus).

— keep a list of biota and the velocity of current where found.

— look for divided eye of Dineatus (whirligig beetles).

— look for species of water strider at tail end of riffles. Rhagovelia species have fan-like rudders on middle tarsus enabling some species to wait in the riffle for drowning insects. Other striders can not live in this current.

— compare diversity of clean stony runs to diversity of silty reaches and pools. Usually diversity is greater in stony runs.

— compare diversity and number of organisms found living among plants to those areas where plants are absent.

— if a lake or pond occurs on a stream, it is useful to study biota at inflow and outflow — often much more below lake due to outflow of plankton which is source of food for other organisms.

— search for organisms living in the gravel bottom itself to a depth of several centimeters.

— monitor chemical, physical, and biological characteristics of the stream on a weekly basis and record fluctuations with the seasons. (See Appendix D)

Procedures

Gary VanDerSchaaf

In this section, we include a sample of activities and questions you may wish to use before, during, and after your field trip. These are suggestions only, and should be modified to fit your needs, knowledge, and budget.

DISSOLVED OXYGEN
and BIOLOGICAL OXYGEN DEMAND
— D.O. and B.O.D.

You may decide that a Hach D.O. kit is beyond your budget. Nonetheless, students should know that the D.O. of the stream is one of the most important abiotic factors involved in stream ecology and should be aware of the relationship between D.O. and the B.O.D. of stream inhabitants. The following exercise, performed in groups or as a class demonstration, shows clearly the cyclical inter-relations of abiotic and biotic factors: abiotic factors (in this case, pollutants) influence biotic factors — the B.O.D. — causing changes that affect the D.O. — an abiotic factor — which in turn will affect all life in the stream.

INTRODUCTION:

Most living things must have some oxygen to live. An organism's need for oxygen is called its *biological oxygen demand* — B.O.D.

You will investigate how the B.O.D. of micro-organisms is affected by changes in the water in which they live. Remember, decay organisms — decomposers — and algae feed on waste material, detritus, and many man-made pollutants. (See Appendix C)

Yeast is a micro-organism that uses sugar as a food source. In this experiment, yeast will represent the decomposers and algae in the stream water. Powdered milk contains sugar, and it will represent pollutants that have seeped, washed, or been dumped into the stream.

MATERIALS:

two packages of yeast
teaspoon
three large test tubes
stopwatch or timer
powdered milk
two baby food jars
methylene blue indicator
eyedropper

PROCEDURE:

1. Prepare a "sewage sample" by mixing one heaping teaspoon of powdered milk into 30 ml of tap water in a baby food jar. Label this jar "sewage."
2. Prepare a "decomposer/algae sample" by mixing one heaping teaspoon of yeast into 30 ml of tap water in a baby food jar. Label this jar "algae." After a minute, stir again to make sure yeast is completely dissolved.
3. Label the test tubes "1," "2," and "3." Into tube 1, pour 4 ml of "sewage," 8 ml into tube 2, and 12 ml into 3.
4. Add 25 drops of methylene blue to each tube. Mix well. Methylene blue is called an indicator because its blue color indicates the presence of dissolved oxygen. If methylene blue is added to a liquid containing dissolved oxygen, and if the oxygen is

used up, the blue indicator will become colorless. Look at your three sewage-methylene blue test tubes. Does each contain oxygen?

5. You are about ready to add the “algae” (the yeast) to the sewage. What do you predict will happen to the blue color in the three test tubes if the algae use the oxygen? In which tube do you predict a color change will first occur?

6. Now add 5 ml of algae solution to the first test tube. Mix well. Record how long it takes for the blue color to begin to disappear and how long it takes for the color to vanish completely. Repeat the procedure for the remaining two test tubes.

	Time for color change to start	Time for color to vanish
Tube 1, 4 ml		
Tube 2, 8 ml		
Tube 3,12 ml		

QUESTIONS:

1. Did you correctly predict in which test tube the color would change soonest? How do you explain the differences in time for the color changes to occur?
2. How do your observations apply to decomposers and algae in streams?
3. Predict what happens to the stream algae population when sewage is dumped or when fertilizers wash into the stream.
4. If the algae/decay organism population grows, what happens to that population’s B.O.D.?
5. If the algae/decay organism population grows, predict what will happen to the stream’s D.O. level, and to other life forms in the stream.
6. Extra credit. Look at your answer to number 5 above. Would your prediction be more likely to hold true in a fast-moving stream or in a slow-moving or stagnant portion of a stream? Why?

TEMPERATURE AND DISSOLVED OXYGEN

Students may wonder why they have to take water temperatures. Part of the answer is that water temperature helps to determine the D.O. level of the water, which level greatly influences the quality and type of life found in the stream. Generally, warm water holds less oxygen than cold water; therefore, warmer water supports life with less stringent B.O.D. demands — “garbage” fish (carp, catfish, and other bottom feeders) and algae. You will wish to discuss the sources and results of thermal pollution with your class in connection with these activities.

INTRODUCTION:

One of the abiotic factors affecting stream life is water temperature. The temperature of the water is just one of the factors that determines the D.O. level of the water, which in turn has a great effect on all life present in the water. Stream water can be heated naturally or artificially, that is, through man’s activities. The sun heats stream water, but it does so unevenly, depending on the rate of flow of the stream and the amount of plant cover overhanging the stream. Sometimes, especially near power plants or factories, men add heated water directly to streams and rivers. This hot water has a great effect on life in the stream or river. This is because warm water does not hold as much oxygen as cooler water. Warm, oxygen-poor water attracts animals that we tend to think of as less attractive: in water with a temperature of 68 degrees F, for instance, you can expect to find carp, catfish, and crappie; you will not find trout or salmon, which thrive in the oxygen-rich waters of cooler temperatures. The experiments below will demonstrate the connection between water temperature and D.O., and the effect of warm-water oxygen deprivation on life in the stream.

Experiments:

Temperature and D.O. (see Appendix C)

MATERIALS:

two packets of yeast
three test tubes
two quart jars of 500 ml beakers
powdered milk
thermometer
timer or stopwatch
ice

PROCEDURE:

1. Prepare and label both a "sewage" and an "algae" sample as described in the D.O./B.O.D. experiment above.
2. Label the test tubes as before.
3. Into each tube pour 10 ml of the sewage solution. Add 25 drops of methylene blue to each tube and mix well.
4. Determine and record the temperature of the contents of each tube. Each tube should be at room temperature.
5. Fill one of the jars or beakers with ice. Fill the other beaker or jar about 3/4 full of tap water.
6. You are about to chill one tube, heat another, and leave the third at room temperature. Predict in which tube the dissolved oxygen will disappear first, after you have added the "algae" in step 8.
7. Put tube 1 in the ice bath. Chill to 10 degrees below room temperature. Put tube 2 in water. Heat to 10 degrees above room temperature. Tube 3 is your control; leave at room temperature.
8. Add 4 ml of "algae" to each tube. Stir. Record, as before, when first color change appears and when color vanishes completely.

	Time for color change to start	Time for color to vanish
Tube 1/		
Tube 2/		
Tube 3/		

QUESTIONS:

1. Did you predict correctly in which tube the dissolved oxygen would vanish first? In which tube and at what temperature did the oxygen disappear first?
2. Why did the oxygen disappear from this test tube first?
3. List three factors that can influence stream water temperature. Often, men will cut down trees along stream and river beds to provide easier access to the water or to

build near the water. What effect would tree removal have on water temperature and life in the water?

4. In addition to decreasing oxygen levels, heated water has other effects on stream life. Discuss what those effects might be. (Hint: many water animals are coldblooded.)

Water Temperature and Fish (see Appendix C)

MATERIALS:

two 500 ml beakers or wide-mouth jars
stopwatch or timer; thermometer
goldfish
baby food jar with lid

PROCEDURE:

1. Fill one of the beakers or wide-mouth jars 3/4 full of tap water.
2. Fill baby food jar with tap water and add the goldfish. Cap the jar.
3. Submerge the baby food jar in the beaker. Put thermometer into beaker, wait for temperature to stabilize, and record it.
4. Determine the activity level of the fish by counting its breathing movements (the opening/closing of the mouth or gills) for 20 seconds. Take and record three such counts. Average and record these counts. Also record on your data sheets the overall activity of the fish.
5. Now, heat the beaker. Heat it until the water temperature is 35 degrees C (95 degrees F), no hotter, and remove the heat source. Then make three 20-second activity counts as you did before. Also, record on your data sheets the overall activity of the fish.
6. After you are finished with your counts, get the fish into some cooler water quickly.

	Breathing Activity	Overall Activity
Room Temp. ____ºC	1.	
	2.	
	3.	
	Avg.	
Heated Water 35ºC	1.	
	2.	
	3.	
	Avg.	

QUESTIONS:

1. Compare the breathing and overall activity of the fish and the two temperatures of your experiment.
2. Remembering what you know about temperature and D.O. and that a fish is a cold-blooded animal, give two reasons why the fish showed increased activities at the higher temperature.
3. What do you think happens to some water animals that are trapped in warm water areas?

4. Predict what will happen to a fish's activity level if you were to cool the water slowly. If time allows, set up and perform that experiment.

SUGGESTIONS FOR DATA SHEETS, ACTIVITIES, AND QUESTIONS

The following are examples of data sheets, activities, and questions you may wish to use. Make any additions or deletions suitable to your needs.

STREAM DATA AND ACTIVITY SHEET

Name and date: ________________________

Stream name: _________________________

I. Abiotic Characteristics

A. Describe plant life along stream bed — grass, emergent plants, trees.

B. Describe the streambed — silt, sand, muck, gravel/ rock, bedrock.

C. Before you start tramping in the stream, observe water clarity. Is it clear or murky?

D. Water tests

Location of Water Sample (edge/mid)	Time	Water Temp.	pH	Dissolved Oxygen (ppm)

E. Determination of stream flow — see attached activity sheet (appendix A).

II. Biotic characteristics

A. Flora

1. Count, and if you can, name the different kinds of plants in your part of the stream. Count only plants in or growing out of the water. Do not forget any visible algae.
2. Are most of the plants in your area firmly rooted or are they free-floating?
3. What kind of stalks predominate — stiff or pliable?
4. Describe any structures that enable the plant to live in its aquatic environment.
5. Take a water sample in a baby food jar to examine in the classroom for microscopic plants and animals.

B. Fauna — Collect as many types of aquatic animals as you can. Identify them on the spot if you are able. Be sure to check stream bottom, on and around plants, on and under rocks. Label all samples. Record findings below. (See attached activity sheet # 2, appendix A)

QUESTIONS:

Note to the teacher: The questions in the first section are group questions; each team should answer these on its own. The questions in the second section can be answered only or best if the data of all the teams is compiled and presented to the class.

I. **Group Questions.**

A. Discuss how the rate of flow in your area influenced:

1. quantity/type/structures of plant life.
2. quantity/type/structures of animal life.

B. Discuss how type of stream bed in your area influenced:

1. quantity/type/structures of plant life.
2. quantity/type/structures of animal life.

C. Taking one example of plant life and one example of animal life, describe the structures and/or behaviors of each that enable it to live in its environment.

D. From your observations of the stream and its surrounding area, what are the sources of food energy for your area of the stream?

E. Construct a three-level food chain for your area of the stream.

F. Why do you think were you asked to record the time of day at which you took your samples? What changes in the characteristics of a stream might take place throughout a day?

II. Class Questions:

A. In which portion of the stream was the most life found? Why do you think this is?

B. Were abiotic factors like pH, temperature, and D.O. constant throughout the stream? Between which two areas of the stream do the greatest differences occur? Offer explanations for these differences.

C. What were the most common aquatic plant and the most common aquatic animal found? Why do you think these organisms are so successful in the stream environment?

D. Draw a food web of the stream.

E. List all evidence of human interference or modification of the stream. Did you see any direct pollution — sewer dumps, garbage? Was there any evidence that surface run-off pollution is possible? With your teacher's help, determine into which river the stream empties, and trace this river as far as you can.

Procedures

Dave Harbach

FAUNA AND FLORA

INTRODUCTION:

A healthy stream will be rich with God's creatures of numerous sizes and shapes. From the stickleback fish (an inch long) to the tiny hydra attached to the underside of a submerged branch, a whole new world of bustling life exists in a stream. The greatest joy of examining a stream is found in the exciting study of its biota. Each dead leaf, rock, plant, scoop of sand or mud reveals an abundance of life that brings to your soul the thought that our God is a great God, the only God in heaven and on earth.

If you were a creature that lived along the bank of a stream you might be the arrowhead plant, with your roots submerged in the rich mud at the edge of a stream while your stem and leaves would stick out gracefully above the water. The arrowhead plant serves as a home to many adult insects, including caddisflies, moths, dragonflies, and stoneflies. The submerged stems may provide shelter for frog and snail eggs, diving beetles, and leeches. A short distance above the water, the cocoons of the whirligig beetle can be found. The dead leaves of these plants along the sides of the stream also serve as home to the same creatures, so be sure you examine them too.

Life in the fast stream has its own unique creatures that survive the pounding force of the rushing water and that build homes on rocks, stones, or pebbles. The water penny with its sleek, flattened body grazes on the green algae and water moss that cover the rocks with a layer of slimy, slippery carpet. Caddisfly larvae scurry between the rocks looking for small bits of sand and leaves to decorate their half-inch long silken cases, which serve as home. The case, sometimes glued onto the underside of a rock, is open at one end so that the caddisfly can back into the home and dart out the opening to grab food that comes rushing by. Some caddisfly larvae scour the streambed carrying their cases with them. Not to be forgotten are the stonefly, blackfly, and mayfly larvae which eat the shredded bits of leaves that rush downstream. You may also find small worms wiggling on submerged rocks. Be sure to search in the algae and moss for tiny creatures hiding there.

Life in the slow stream has its own dangers. The water tiger, which is the larva of the diving beetle, hunts for its prey, usually a small fish, sucking enough blood to kill its victim. Dark brown in color, the adult diving beetle, which is easily seen, also attacks fish. The water scavenger beetle larva, the spearmouth, exhibits the same habits as the water tiger, except that the adult beetle feeds on dead plants and animals. Then there is the dragonfly nymph which is small enough to go through a strainer but grows into a larva almost two inches long. Waiting in elodea or on the stream bottom, the dragonfly larva pounces forward, extending a pincherlike organ that grabs and holds the victim so that the dragonfly larva can devour its food. Floating on the water is the water strider which feeds on helpless insect victims that have fallen into the water. The water scorpion resembles the water strider but lives most of its life in mud. The largest insect under the water is the giant water bug which patiently waits on the bottom of a stream pool for its dinner to happen by. The giant water bug also flies and can be seen at night around electric lights. The adult whirligig beetle, water boatman, and back swimmers will occasionally inflict a severe bite on fish. None of these insects should be put into an aquarium containing pet fish because in a short time, even overnight, they can devour or injure all of the fish in the fish tank. Neither should you put hydra into a young fish aquarium, for they poison the fish. Larger fish eat these dangerous insects so that they do not kill off all of the small fish.

Less threatening, freshwater clams, limpets, crayfish, tubiflex worms, mosquito larvae, snails, midges, and leeches can be found living their lives out in the slow-moving part of a stream.

Not to be forgotten are the millions of diatoms, desmids, and green algae, the phytoplankton, that live by photosynthesis and form the basis for the food web. Zooplankton (e.g., daphnia, paramecium, and cyclops) feed on the phytoplankton. The zooplankton are in turn eaten by insects and fish, which are eaten by larger fish and frogs, which are eaten by snakes and larger animals. This makes up the food web where the ecosystem is kept in balance.

Many more creatures exist for you to explore and discover in a stream. Care should be taken when approaching a stream. Walk quietly and stop to listen to rustling near the stream. Who knows, maybe you will come upon a deer, fox, or weasel drinking stream water!

PRE-TRIP

Provide the students with books on stream or pond biota. They need to become familiar with the books so that they will be able to identify the creatures they will be collect ing. Filmstrips, films, etc. will also help the students to know the creatures they will be hunting for. Live specimens will give the students a real-life look at stream critters, so prepare for each student small dishes in which to observe the creatures of the stream.

ON-SITE

All members of the group should spend time examining and collecting the different types of plants and animals found at each stream study area. In riffle areas and falls, look at the top and undersides of rocks. Put a sample of the biota in a collecting jar. You might have to scrape off some of the algae for a sample or carefully dislodge tiny hydra to observe later. Also remember to scrape with a small net the undersides of fallen trees that are partly under water to collect samples for study, which may include a small fish as a bonus. In sandy bottom and gravel bottom areas, use a shovel to dig up a small amount of the stream bottom and place it in a pan for study. Carefully go through the small amount of stream bottom with your fingers or a stick and record the types of animals present. Remember to put some of these organisms and algae in a sample jar. In stagnant pools of water, dip the sample jar in the water and put samples of the green algae in the jar. Dig down in the muck and carefully look for squiggling creatures. Stagnant pools of water often provide the greatest amount of microscopic biota to study. In all areas, take a sample of the stream water back to the classroom for study under the microscope. Try to draw pictures of the creatures you see. A Polaroid picture or video of each area you visit will also help you to recall what was present at each stream study area.

POST-TRIP

Examine the various samples of each stream study area. Look at, record, and draw the organisms you see using and not using the microscope and magnifying glass. Use the data sheet or blank index cards on which to draw your pictures.

As a whole classroom activity comparing results, each group should report what biota they found in a specific stream study area in order to come to a consensus as to the type of organisms found in that stream study area. Repeat this procedure for each study area, i.e., riffle, pool, and head waters.

Experiment:

How about a challenge? Caddisfly larvae can be kept in an aerated culture tank and observed as they build homes. Here is what to do (see Appendix C):

MATERIALS:

Caddisfly larvae (preferably trichopteron larvae)
culture tank or an aquarium that has air bubbling in it

While at the stream site, collect not only the caddisfly larvae but also plant material such as duckweed, elodea, and green algae. A good source of diatoms will also help to feed the caddisfly larvae.

Wood, leaf, and stem fragments should be gathered along with sand and silt particles to be placed in the aquarium. Pine needle parts are also useful.

Man-made materials that can be used for case building are wax paper, polyethylene, and aluminum foil.

METHOD:

Keep the water at room temperature. Place the caddisfly larvae in the prepared culture tank or aquarium that is aerated.

If a caddisfly larva is already in its case, then carefully eject the larva from the case by pressing a blunt object through the, closed end of the case. Watch the larva. Did the larva find and return to its own case?

If the caddisfly larva is by itself, place it in the tank and watch it build its own case. What materials did it use to build its case? What size of materials did it use to build its case?

* * * * * *

Dump the contents of the collection jars into a white vessel or into a clear-bottom vessel that is on white paper. Have the students classify the organisms they see according to shape, size, body parts, and color.

Provide paper or index cards, on which the students will draw the creatures they see. This can also include the microscopic organisms. Construct a food chain by using the drawings of the creatures. Put the smaller creature cards on one half of the table top and the larger creature cards on the other half of the table top. Have the students arrange the cards as to which creatures might eat the other creatures. Place colored yam between these cards or draw lines between cards if the table top is covered with white paper. Why did they place the creatures in the order they chose? Remember to start the food web with plants such as diatoms, desmids, or algae.

DISSOLVED OXYGEN

INTRODUCTION:

The dissolved oxygen is the amount of oxygen between molecules of water. The dissolved oxygen is the oxygen that organisms can use to live in the stream. The riffle area that produces choppy water will have a higher amount of dissolved oxygen than a smooth water area with a sandy bottom. A smooth water area away from a riffle area does not agitate the water enough to cause large amounts of oxygen from the air to be dissolved in it. As a result, the slower moving part of the stream with a sandy or muddy bottom will have less dissolved oxygen for organisms to use. This fact affects the kinds of organisms that live in the riffle and sandy bottom areas of the stream so profoundly that organisms that live in a riffle area may not survive in a sandy bottom area because there is not enough dissolved oxygen in the water in a sandy bottom area for the riffle organism to use. The opposite is also true. A riffle area may have too much dissolved oxygen in it for a sandy bottom organism to survive.

There is more dissolved oxygen in a colder water temperature than in a warmer water temperature. A slow-moving part of the stream that is overgrown with trees will have more dissolved oxygen in the water than a similar slow-moving part of the stream that is exposed to direct sunlight. A cooler water temperature holds the dissolved oxygen more than a warmer water temperature. Because of this fact, any water added to a stream should be at the same water temperature as the stream. Adding an abundance of warmer water to a stream will change not only the ecosystem of that area of the stream but also the dissolved oxygen content of the water, which may prove harmful to benthic organisms.

PRE-TRIP

To introduce students to dissolved oxygen, obtain a test kit and follow the directions for determining the amount of dissolved oxygen in water from an aquarium or faucet.

Determine the D.O. content of ajar of water that has not been agitated for a couple of days. Then stir the water vigorously for five minutes and immediately determine the D.O. content, comparing the results. Which water condition had more D.O. content?

ON-SITE ACTIVITY

The D.O. content does not have to be determined, but if you do it, then follow the directions on the dissolved oxygen kit carefully. In the lower grades, the teacher will need to use the kit to find out the dissolved oxygen in the stream water. Measure the dissolved oxygen in parts per million or mg/L and record on the data sheet. Dissolved oxygen is an important factor in determining the kinds of organisms that can live in a stream study area.

POST-TRIP

You will want to graph the % saturation of the D.O. content of the sites you studied. In order to determine the % saturation of D.O. you need to use a nomogram, mentioned elsewhere in these writings (see appendix B), which has three scales on it: water temperature, % saturation, and oxygen content in mg/liter. The D.O. test kit will determine the D.O. in mg/liter. Taking the data from one site, find and mark the oxygen in mg/liter on the bottom scale and the water temperature on the top scale. Lay a ruler across the two marks and read the % saturation of D.O. where the ruler crosses the % saturation scale. Mark this point on the graph that compares water temperature and % saturation. (See Appendix B)

Which site provided the higher % saturation of D.O.?

When the temperature of the water increases, what happens to the % saturation of dissolved oxygen in the water?

Compare the types of organisms found in a site with the highest D.O. (e.g., a riffle), and the site with the lowest D.O. (e.g., a small pool). The riffle should provide an abundance of dissolved oxygen-loving organisms whereas the small pool will provide an increase in algae and organisms that do not need as much dissolved oxygen.

Riffle areas of the stream have biota that can live in a fast current and can withstand higher amounts of dissolved oxygen. Most fauna in a riffle, therefore, will have body parts that enable them to attach to the undersides of rocks and gravel, where they live without being swept away by the water current. These fauna have a more streamlined body. The flora of the riffle area is predominately green algae and water moss. The algae grows on the top surface of rocks where it can carry on photosynthesis. Because of the swift current, this algae is slimy and very slippery to handle. The dissolved oxygen content of the water is probably not as important a factor for the flora as it is for the fauna.

There is a debate as to the purpose of having a streamlined body, that is, a small flat body. Some scientists think that the body is slim so that the water will flow quickly over the organism, producing less force on the organism so that it is not swept away in the fast current. Other scientists explain the slim body as necessary in order for the organism to enter what is called the boundary layer around rocks where the force of the current of water is greatly reduced. The flat body enables the organism to enter this boundary layer where it can stay and move about without being swept away in the stream current.

STREAM DEPTH AND WIDTH

INTRODUCTION:

Stream depth and width measurements help to determine the amount (volume) of water flowing in a stream. The volume of water flowing in a stream will affect the tempera ture of the stream and the ability of a stream to clear itself after being polluted by man or after a heavy rainstorm.

PRE-TRIP

Practice measuring the width of the room and other large objects in meters and feet, so that the students know how to use a meter stick or long tape measure.

For practice in depth measuring, measure the height of various objects in the room. To make measuring more interesting, fill five jars with different amounts of water and measure their depths. If it rains, try measuring the depths of water puddles on the school grounds.

ON-SITE

Use a meter stick to find out the depth of the stream. In the middle of the stream, place the zero-end of the meter stick on the bottom of the stream and find the centimeter number where the top of the stream water touches the meter stick. An average depth can be found by measuring the depth of the stream at fifty centimeter distances beginning from the stream edge and going across the stream in a straight line to the opposite stream edge. Average depth is figured by adding all of the depths for a total depth and dividing the total depth by the number of depths recorded. Record the results on the data sheet (Appendix D).

An easier method to determine stream depth, but less accurate, is to measure the depth of the stream at the middle of the stream and .5 meters near both sides of the stream. These three measurements can then be totaled and divided by 3 to get an average depth in meters which you record on the data sheet (see Appendix D).

To determine the width of the stream use a tape measure or meter stick. Find out the distance from one side of the stream to the other side. Record the width in meters on the data sheet (see Appendix D).

POST-TRIP

For your convenience, I am including this part about volume of flow also in the post-trip section of Rate of Flow.

By multiplying the measurements of the width of the stream, times its depth, times its velocity we can calculate the volume of water flow in the stream. It will be necessary to perform a few mathematical calculations in order to determine volume of flow in cubic meters per second or cubic feet per second. Use the values from the data sheet (see Appendix D) to determine volume of flow.

The volume of flow is determined by the following formula:

R=WDV,

that is Volume=width x average depth x velocity

R = ___ meters (width) x ___ meters (average depth) x ___ meters/sec. (velocity)

Volume of flow = ___ cubic meters/second

Now, fill in the graph for rate of flow and volume of flow (see Appendix B). Draw a blue line from point to point for rate of flow and draw a red line from point to point for volume of flow. What happens to the volume of flow when the rate of flow increases? The formula for volume of flow can also be calculated in cubic feet per second.

What kinds of organisms lived in the faster part of the stream? What shapes did they have?

What kinds of organisms lived in the slower part of the stream? What shapes did they have?

RATE OF FLOW (VELOCITY)

INTRODUCTION:

The rate of flow forms each specific study area. The faster the current of water, the less silt and sand will be able to settle to the bottom of the stream. As a result, more gravel, rocks, and bedrocks will be found in the stream bottom. The riffle area has the highest rate of flow, whereas the sandy bottom area of the stream will have the lowest rate of flow. The higher rate of flow therefore produces a stream bottom with gravel and rocks that serve as home to organisms that can live in fast water currents and under rocks. The lower rate of flow produces a stream bottom that is sandy or muddy that serves as home to organisms that can live in slower water currents and that can burrow into the sand or mud.

PRE-TRIP

Though this may appear strange, practice rolling an orange down the hall in school or down a hill outside of school. Using a stopwatch, start the time when the orange begins to roll and stop it when it goes past a determined end point. Record on a sheet of paper the distance and the time (seconds) it took the orange to travel that distance (centimeters or meters). Rate of flow is determined by the following equation:

$$ROF = m/sec,$$

where the distance in meters is divided by the time in seconds.

This information is necessary in order to compute the volume of flow later on.

ON-SITE ACTIVITY

Two students, the distance measurer and the time reader, will be needed to measure the rate of flow or velocity of the stream water. At a specific site, e.g., a riffle area, first measure the distance in centimeters or meters along the riffle area from a starting point to an ending point and record the distance on the data sheet (see Appendix D). Make sure no objects will stop the orange. Hold an orange in the stream at the first point. Start the time when you let go of the orange at the starting point and stop the time when the orange gets to the ending point in the stream. Record the time in seconds on the data sheet (see Appendix D). You could do this more than once using the same starting and ending points to get an average time.

POST-TRIP

The rate of flow or velocity and the amount of dissolved oxygen in the water determine to a large degree the amount and kinds of organisms that live in a stream.

Notice that the rate of flow is greater in a riffle area than in a pool area and that the dissolved oxygen content is likewise greater in a riffle than in a pool.

What effect does a riffle have on the dissolved oxygen content of the water as compared to a pool? Why do you think it has this effect?

By combining the measurements of the width of the stream, its depth, and velocity we can calculate the volume of water flow in the stream. It will be necessary to perform a few mathematical calculations in order to determine volume of flow in cubic meters per second or cubic feet per second. Use the values from the data sheet (Appendix D) to determine volume of flow.

The volume of flow is determined by the following formula:

$$R = WDV,$$

that is, Volume = width x average depth x velocity

R = ___ meters (width) x ___ meters (average depth) x ___ meters/sec. (velocity)
Volume of flow = ___ cubic meters/second

Now, fill in the graph for rate of flow and volume of flow (Appendix B). Draw a blue line from point to point for rate of flow and draw a red line from point to point for volume of flow. What happens to the volume of flow when the rate of flow increases?

What kinds of organisms lived in the faster part of the stream? What shapes did they have? What body parts helped them to live in the faster current?

What kinds of organisms lived in the slower part of the stream? What shapes did they have? What body parts helped them to live in the slower current?

What kinds of organisms lived in the bottom of the stream? What shapes did they have? What body parts helped them to live in the bottom of the stream?

Most organisms in a riffle will have body parts that enable them to attach to the undersides of rocks and gravel. These biota will be more streamlined in appearance.

There is a debate as to the purpose of having a streamlined body, that is, a small flat body. Some scientists think that the body is slim so that the water will flow quickly over the organism, producing less force on the organism so that it is not swept away in the fast current. Other scientists explain the slim body as necessary in order for the organism to enter what is called the boundary layer around rocks where the force of the current of water is greatly reduced. The flat body enables the organism to enter this boundary layer where it can stay and move about without being swept away in the stream current. In either case, the streamlined body shape is an advantage for an organism that lives in a riffle, because the fauna are able to attach themselves to rocks and gravel without being carried downstream to a pool area of the stream.

WATER TEMPERATURE

INTRODUCTION:

The temperature of the stream water does determine the kinds and amount of organisms living in a specific area of the stream. An organism living in a stream will grow to maximum size within a preferred temperature range of water. Water temperatures lesser or greater than the preferred temperature not only reduce the growth size of an organism but may also kill that organism. The different organisms present in a stream prefer different water temperatures for growth and survival. Brook trout prefer cooler water temperatures for maximum growth size and living than do largemouth bass which require warmer water temperatures.

Water temperature in a stream varies along its course. Long stretches of the stream that are protected with dense tree growth will have a lower water temperature whereas long stretches of the stream that are exposed to the sun will have a warmer water temperature. This difference in water temperature will mean a difference in the amount and kinds of creatures living in the stream ecosystem. It is therefore important to take notice of the site characteristics along the course of a stream.

Read the introduction to dissolved oxygen (p. 20) for further information on water temperature.

PRE-TRIP

One of the goals of the pre-trip is to provide practice at reading a centigrade thermometer. In one of five jars, put very cold water. In the next four jars, put water of different temperatures. Allow the students time to practice reading and recording the temperatures in the five jars.

Another goal is to show the difference in activity of organisms in cold vs. very warm water. Take pond water that has living organisms in it and put it in three jars. If you do not have access to pond water, use tap water and a small fish in each jar. Put one jar in the refrigerator to cool it down to 10 degrees Celsius. Leave the next jar at room temperature and slowly heat the last jar to 32 degrees Celsius. Observe the activity of the organisms in each jar for a few minutes and record your results. If you are using fish, return the fish to their normal water temperature immediately after you finish observing their activity.

Ask these questions:

Which water temperature decreased the activity of the organisms? Why?

Which water temperature increased the activity of the organisms? Why?

ON-SITE

Determine the temperature of the air and water. While at the stream study-site, hold the centigrade thermometer in the air and record the temperature in degrees centigrade on the data sheet (Appendix D). Determine the water temperature by carefully placing the thermometer in the stream without dropping it or hitting objects under the water. After a minute, read the thermometer and record the temperature on the data sheet (Appendix D). Try determining the water temperature in sunny and shaded areas of the same stream study-area to see if there is a difference in water temperature.

POST-TRIP

Using the data sheets, look for two sites that have differing water temperatures. Determine if there is a difference in the kinds of biota living at each site.

What organisms live in the warmer water? What shape do they have? What body parts help them to live in the warmer water?

What organisms live in the colder water? What shapes do they have? What body parts help them to live in colder water?

Mark the temperatures on the graph for each site and also mark the dissolved oxygen content on the graph. Connect the marks for temperature using a blue line and connect the marks for dissolved oxygen using a red line. What happens to the dissolved oxygen as the temperature increases?

In what water temperature was the blue-green and green algae more abundant?

SUGGESTED ACTIVITIES:

1. Take samples of the biota found in riffles, sandy beds, gravel beds, falls, and stagnant pools. Put these samples in a plastic jar for later use. Fill in the biota information on the data sheet for each stream-study area (Appendix D).
2. Study temperature, rate of flow, pH, and dissolved oxygen in the same areas as in one of the above. Use the data sheet to fill in the abiotic information in each stream-study area.
3. Study the number of caddisfly or mayfly in relation to the distance from shore, various rates of flow, characteristics of a stream, temperature, pH, and dissolved oxygen.
4. Make a simple food chain including predators of a stream study-area. Try using three-by-five cards for each organism in the web or chain.
5. Study the home building of various insects, e.g., caddisfly cases, in relation to the rate of flow and type of stream bed.
6. Study water samples under the microscope to identify and draw microorganisms.
7. Draw pictures of the biota and stream beds.
8. After collecting stream samples of water and biota, group organisms according to the number of legs of, the shape of, the size of, the color of, the mouth parts of, the home of an organism. Group organisms as to whether they are consumers or producers. Use several plastic containers in which to group your organisms, making sure that adequate water is provided in each container for the organism to live.
9. For the really ambitious, build a ripple in the classroom using a water pump, rocks, sand, water plants, stream bottom debris, and stream fauna. Make sure the water cascades over the rocks so that air is mixed into the water.
10. A pool area can also be simulated using an aquarium with an air supply, plus all of the goodies mentioned in #9 above.

APPENDIX

APPENDIX A
Activities

KNOW YOUR WORDS

Fill in the missing words with the words at the bottom of this section. Each blank line is a letter of the missing word or words.

1. The amount of silt on a stream bottom changes when the _ _ _ _ of flow changes.
2. A stream shaded by trees has a lower water _ _ _ _ _ _ _ _ _ _ _ than the same stream without trees.
3. The constant churning of stream water over _ _ _ _ _ _ _ and falls increases the oxygen content of the water.
4. The higher the _ _, the more abundant is the aquatic life.
5. The riffle is an ideal site for the production of blue-green and green _ _ _ _ _.
6. A stream that has many riffles to churn the water will have a high _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ content.
7. A stream _ _ _ with lots of sand is a sandy bottom stream.
8. The bottom ooze of a stream has many _ _ _ _ _ _ _ organisms.
9. The area of the interaction of biotic and abiotic factors is called an _ _ _ _ _ _ _ _ _.
10. The _ _ _ _ _ of a stream are the plants and animals that live in the stream.
11. A _ _ _ _ _ _ _ _ _ is the network of animals feeding on one another.
12. You need a microscope to see the _ _ _ _ _ _ _ _ that fish eat.

biota rate bed temperature food chain pH algae benthic plankton dissolved oxygen riffles ecosystem

STREAM DATA AND ACTIVITY SHEET

Name: ______________________________ Date: ___________________

Stream name: ________________________

I. Abiotic Characteristics

A. Describe plant life along stream bed -grass, emergent plants, trees.

B. Describe the stream bed — silt, sand, muck, gravel/rock, bedrock.

C. Before you start tramping in the stream, observe water clarity. Is it clear or murky?

D. Water tests:

Location of Water Sample (edge/mid)	Time	Water Temp.	pH	Dissolved Oxygen (ppm)

E. Determination of stream flow.

1. Measure and mark a 50-foot distance along a straight portion of the stream. If you can not find a 50-foot distance, use a smaller section. Throw an orange into the water above the upstream marker. Record the number of seconds it takes the orange to float downstream between the two markers. Record here: _________ Now divide the 50-foot distance by the total seconds it took the orange to float between the markers.

50' divided by _________ = ____________ feet per second
(distance) divided by (total seconds) = (rate of flow per second)

2. Find the average width of your section of the stream. Measure the width of the stream at three places within the marked 50-foot area. Divide the total of the three measurements to get the average width of the stream.

First measurement: ______ feet.
Second measurement: ______ feet.
Third measurement: ______ feet.
Total: ______ divided by 3 = ______ feet (average width)

3. Find the average depth of your section of the stream. Measure the depth of the stream in three places across the 50-foot area in a straight line. Divide the total of the three measurements to get the average depth of the stream.

First measurement:	______ feet.	
Second measurement:	______ feet.	
Third measurement:	______ feet.	
Total:	______ divided by 3 =	______ feet (average depth)

4. Find the cubic feet of water per second. Multiply the average width, average depth, and the rate of flow.

________ feet	x	________ feet	x	________	=	______________
Average width		Average depth		number of feet/second		cubic feet of water

(Note: A cubic foot of water is the water in a container 1 foot wide, 1 foot high, and 1 foot long, and contains 7.48 gallons.)

5. In order to find out how many people could live from the water in this stream, complete the following calculations.

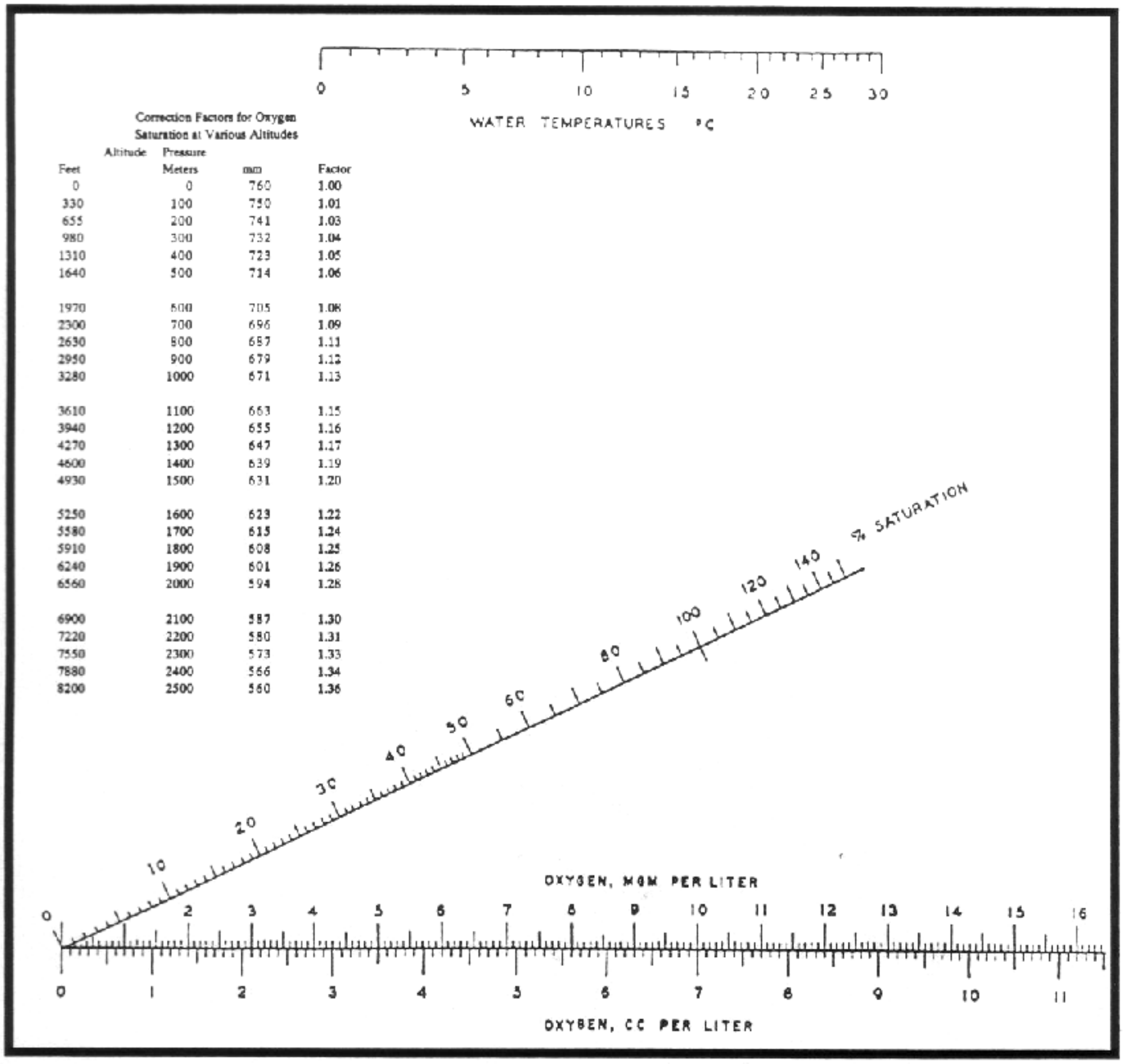
______________________	x 7.48 =	____________________________
stream flow in cubic feet/second	gallons in 1 cubic foot of water	gallons of water flowing per second

* The average American uses about 300 gallons of water a day for home use. This figure does not reflect each person's share of water used for industrial, public services, and commercial purposes per person.

STREAM ACTIVITY SHEET # 2

sample number	WHERE FOUND						name	number	
	on the surface	hanging from the surface	free swimming	on or among vegetation	on the bottom	in the bottom sediments			

APPENDIX B
Charts

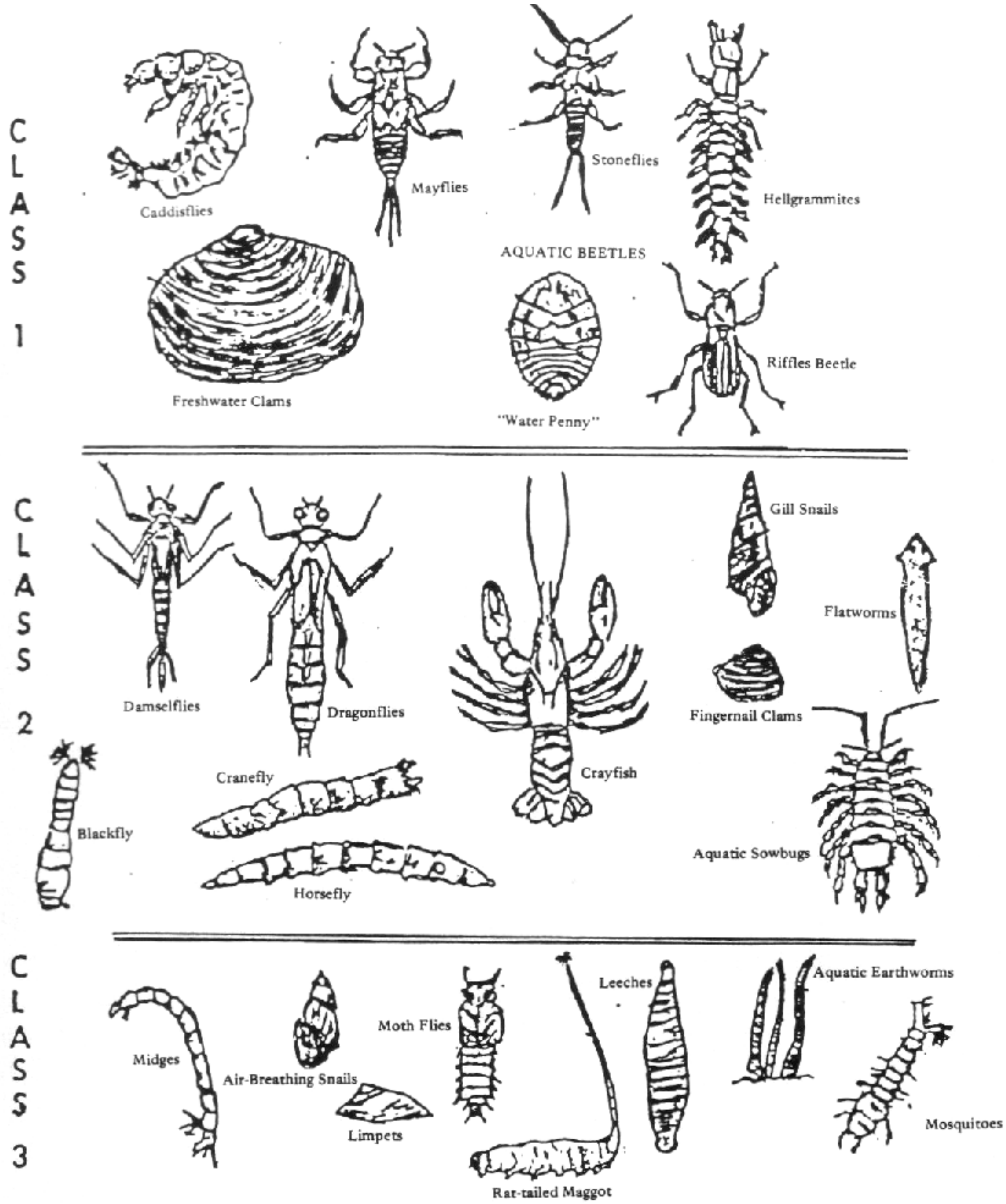


Correction Factors for Oxygen Saturation at Various Altitudes

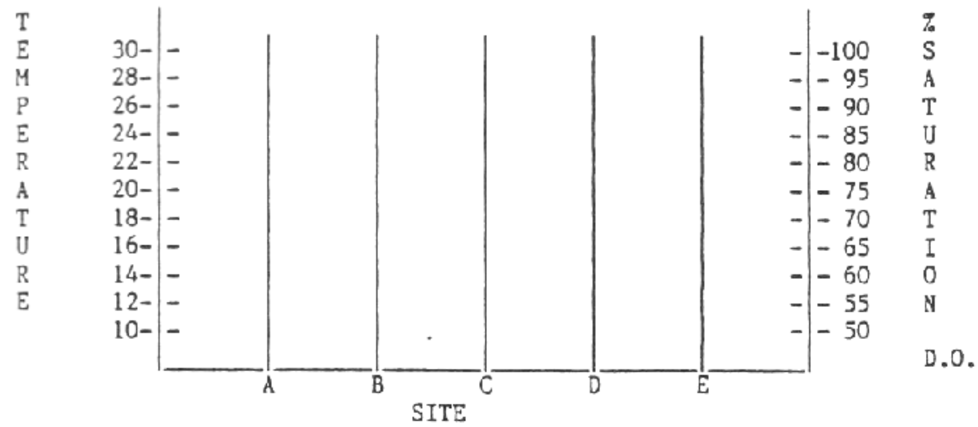
Altitude Feet	Meters	Pressure mm	Factor
0	0	760	1.00
330	100	750	1.01
655	200	741	1.03
980	300	732	1.04
1310	400	723	1.05
1640	500	714	1.06
1970	600	705	1.08
2300	700	696	1.09
2630	800	687	1.11
2950	900	679	1.12
3280	1000	671	1.13
3610	1100	663	1.15
3940	1200	655	1.16
4270	1300	647	1.17
4600	1400	639	1.19
4930	1500	631	1.20
5250	1600	623	1.22
5580	1700	615	1.24
5910	1800	608	1.25
6240	1900	601	1.26
6560	2000	594	1.28
6900	2100	587	1.30
7220	2200	580	1.31
7550	2300	573	1.33
7880	2400	566	1.34
8200	2500	560	1.36

FIGURE 9.1. **A Nomogram for Determining Oxygen Saturation Values at Various Temperatures and Altitudes.** In practice, a straightedge is used to connect observed temperature and dissolved oxygen concentration. The point of intercept on the inclined scale gives the percent of saturation. Correction for altitude is made by applying the factors given in the table in the upper left. (From Rawson, D.S., 1944. "The Calculation of Oxygen Saturation values and Their Correction for Altitude," *Limnol. Soc. Am. Spec. Publ.*, No. 15.)

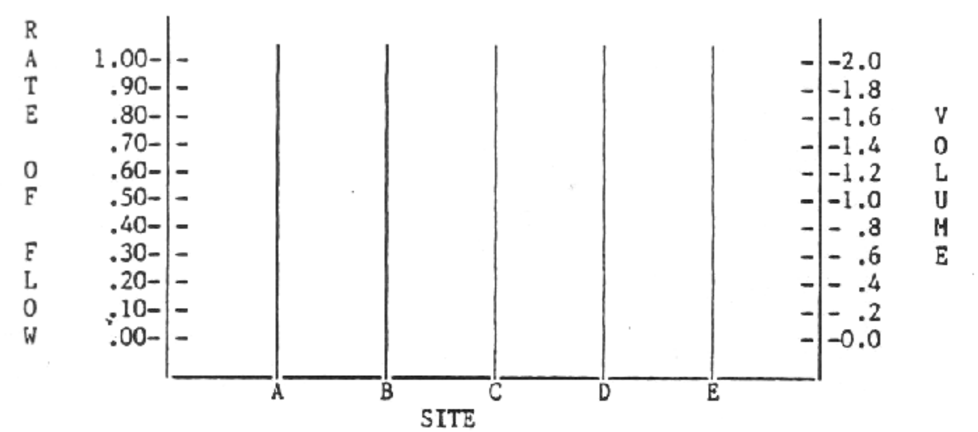
BIOTIC INDEX BENTHIC ORGANISMS



GRAPHS



According to the graph above, as the temperature increases, what happens to the % saturation of the dissolved oxygen?

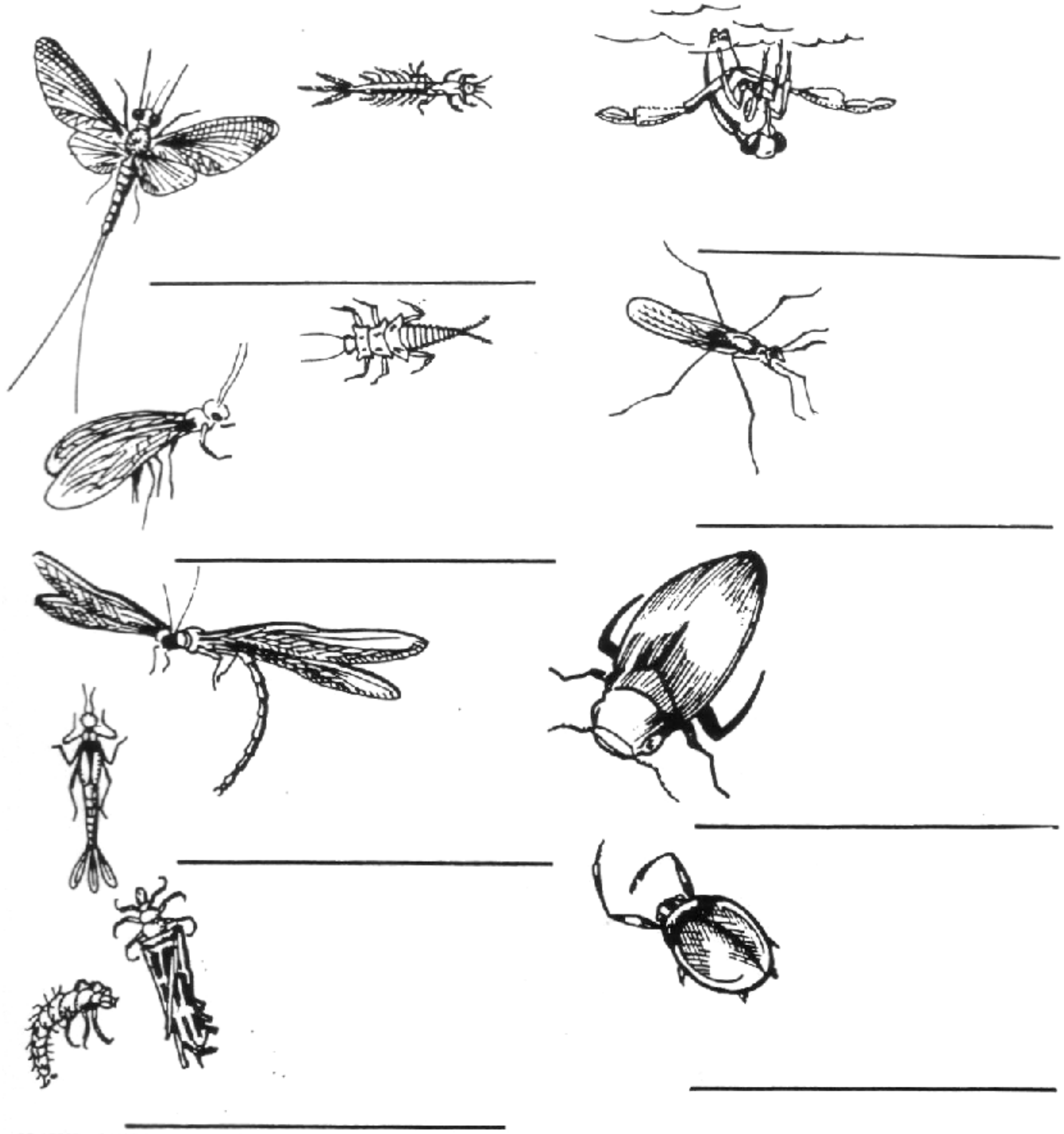


In the graph above, as the rate of flow increases, what happens to the volume of flow?

Name ____________________

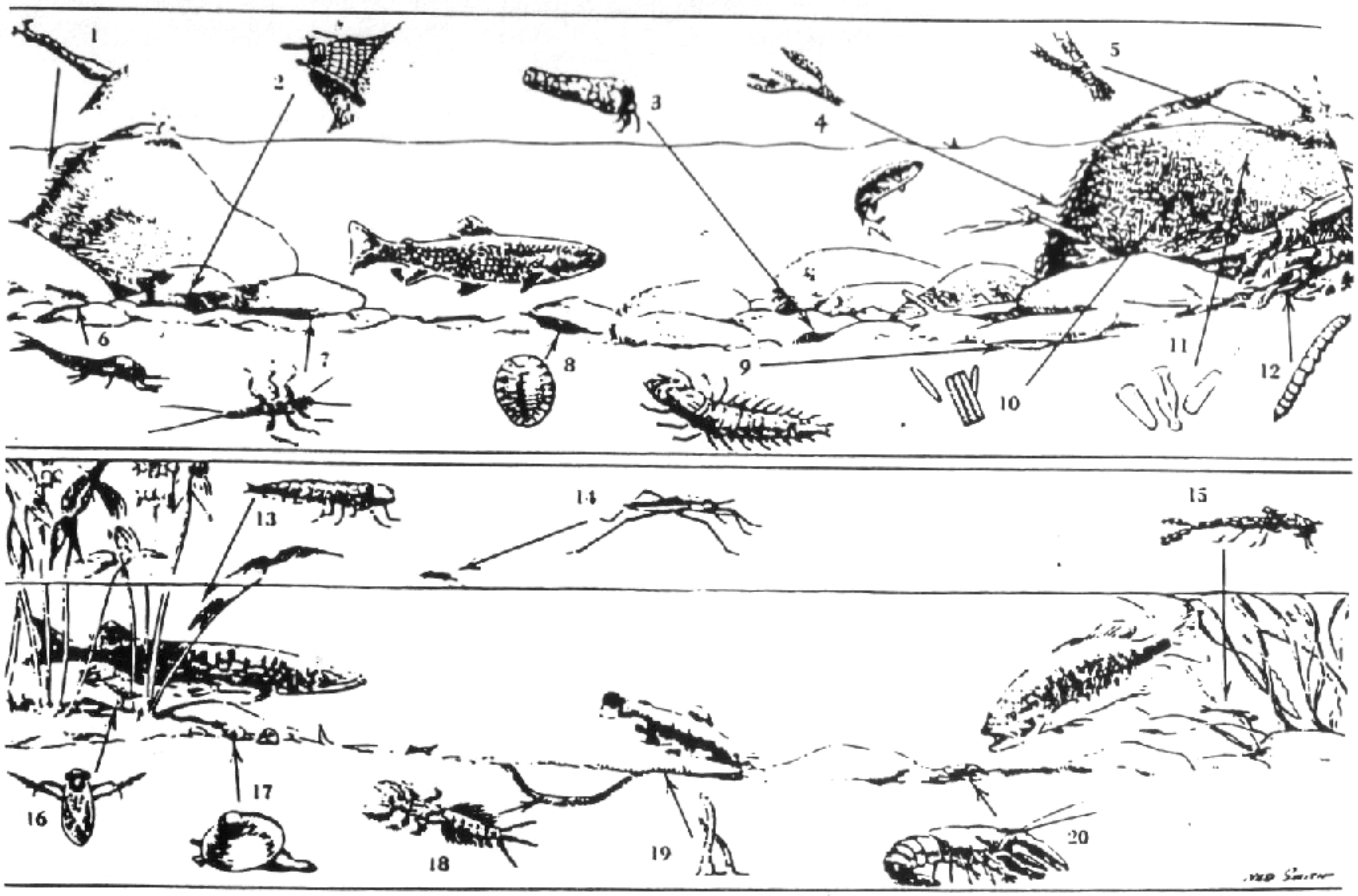
COMMON WATER INSECTS

Identify these common water insects.



WORD BANK

caddisfly	mayfly	stonefly
damselfly	diving beetle	water strider
backswimmer		whirligig beetle



Life in a Fast Stream Compared to that in a Slow Stream

(1) Blackfly larva; (2) net-spinning caddisfly; (3) stone case of caddisfly; (4) water moss (Fontinalis); (5) alga Ulothrix; (6) mayfly nymph (Isonychia); (7) stonefly nymph (Perla); (8) water penny; (9) hellgrammite; (10) diatoms (Diatoma); (11) diatoms (Gomphonema); (12) cranefly larva; (13) dragonfly nymph; (14) water strider; (15) damselfly nymph; k 16) water boatman; (17) fingernail clam (Sphaerium); (18) burrowing mayfly nymph (Hexagenia); (19) bloodworm, (2U) crayfish. The fish in the fast stream, above, are (left) brook trout, (right) redbelly dace. The fish in the slow stream, below, are (left to right) northern pike, bullhead, smallmouth bass.

APPENDIX C
Experiments

How the Biological Oxygen Demand (B.O.D.) is affected by changes in the water.

Materials:

two packages of yeast
teaspoon
three large test tubes
stopwatch or timer
powdered milk
two baby food jars
methylene blue indicator
eyedropper

Procedures

1. Prepare a "sewage sample" by mixing one heaping teaspoon of powdered milk into 30 ml of tap water in a baby food jar. Label this jar "sewage."
2. Prepare a "decomposer/algae sample" by mixing one heaping teaspoon of yeast into 30 ml of tap water in a baby food jar. Label this jar "algae." After a minute, stir again to make sure yeast is completely dissolved.
3. Label the test tubes "1," "2," and "3." Into tube 1, pour 4 ml of "sewage," 8 ml into tube 2, and 12 ml into 3.
4. Add 25 drops of methylene blue to each tube. Mix well. Methylene blue is called an indicator because its blue color indicates the presence of dissolved oxygen. If methylene blue is added to a liquid containing dissolved oxygen, and if the oxygen is used up, the blue indicator will become colorless. Look at your three sewage-methylene blue test tubes. Does each contain oxygen?
5. You are about ready to add the "algae" (the yeast) to the sewage. What do you predict will happen to the blue color in the three test tubes if the algae use the oxygen?

   In which tube do you predict a color change will first occur?

6. Now add 5 ml of algae solution to the first test tube. Mix well. Record how long it takes for the blue color to begin to disappear and how long it takes for the color to vanish completely. Repeat the procedure for the remaining two test tubes.

	Time for color change to start	Time for color to vanish
Tube 1, 4 ml		
Tube 2, 8 ml		
Tube 3,12 ml		

Questions:

1. Did you correctly predict in which test tube the color would change soonest? ________ How do you explain the differences in time for the color changes to occur?

2. How do your observations apply to decomposers and algae in streams?

3. Predict what happens to the stream algae population when sewage is dumped or when fertilizers wash into the stream.

4. If the algae/decay organism population grows, what happens to that population's B.O.D.?

5. If the algae/decay organism population grows, predict what will happen to the stream's D.O. level, and to other life forms in the stream.

6. **Extra credit:** Look at your answer to number 5 above. Would your prediction be more likely to hold true in a fast-moving stream or in a slow-moving or stagnant portion of a stream? Why?

Temperature and Dissolved Oxygen (D.O.).

Materials:

two packets of yeast	powdered milk
three test tubes	thermometer
two quart jars of 500 ml beakers	timer or stopwatch
methylene blue indicator	ice

Procedure:

1. Prepare a "sewage sample" by mixing one heaping teaspoon of powdered milk into 30 ml of tap water in a baby food jar. Label this jar "sewage."
2. Prepare a "decomposer/algae sample" by mixing one heaping teaspoon of yeast into 30 ml of tap water in a baby food jar. Label this jar "algae." After a minute, stir again to make sure yeast is completely dissolved.
3. Label the test tubes "1," "2," and "3." In each tube pour 10 ml of the sewage solution. Add 25 drops of methylene blue to each tube and mix well.
4. Determine and record the temperature of the contents of each tube. Each tube should be at room temperature.
5. Fill one of the jars or beakers with ice. Fill the other beaker or jar about 3/4 full of tap water.
6. You are about to chill one tube, heat another, and leave the third at room temperature. Predict in which tube the dissolved oxygen will disappear first, after you have added the "algae" in step 8.
7. Put tube 1 in the ice bath. Chill to 10 degrees below room temperature. Put tube 2 in water. Heat to 10 degrees above room temperature. Tube 3 is your control; leave at room temperature.
8. Add 4 ml of "algae" to each tube. Stir. Record how long it takes for the blue color to begin to disappear and how long it takes for the color to vanish completely.

	Time for color change to start	Time for color to vanish
Tube 1		
Tube 2		
Tube 3		

Questions:

1. Did you predict correctly in which tube the dissolved oxygen would vanish first? In which tube and at what temperature did the oxygen disappear first?

2. Why did the oxygen disappear from this test tube first?

3. List three factors that can influence stream water: a. _____________________, b. _____________________, c. _____________________

Often, men will cut down trees along stream and river beds to provide easier access to the water or to build near the water. What effect would tree removal have on water temperature and life in the water?

4. In addition to decreasing oxygen levels, heated water has other effects on stream life. Discuss what those effects might be. (Hint: many water animals are cold-blooded.)

Water Temperature and Fish

Materials
two 500 ml beakers or wide-mouthed jars
stopwatch or timer
thermometer
goldfish
baby food jar with lid

Procedure:

1. Fill one of the beakers or wide-mouthed jars 3/4 full of tap water.
2. Fill baby food jar with tap water and add the goldfish. Cap the jar.
3. Submerge the baby food jar in the beaker. Put thermometer into beaker, wait for temperature to stabilize, and record it.
4. Determine the activity level of the fish by counting its breathing movements (the opening/closing of the mouth or gills) for 20 seconds. Take and record three such counts. Average and record these counts. Also record on your data sheets the overall activity of the fish.
5. Now, heat the beaker. Heat it until the water temperature is 35°C (95°F), no hotter, and remove the heat source. Then make three 10-second activity counts as you did before. Also, record on your data sheets the overall activity of the fish.
6. After you are finished with your counts, get the fish into some cooler water quickly.

	Breathing Activity	Overall Activity
Room Temp. ____ºC	1.	
	2.	
	3.	
	Avg.	
Heated Water 35ºC	1.	
	2.	
	3.	
	Avg.	

Questions:

1. Compare the breathing and overall activity of the fish and the two temperatures of your experiment.
2. Remembering what you know about temperature and D.O. and that a fish is a cold-blooded animal, give two reasons why the fish showed increased activities at the higher temperature.

____

____

3. What do you think happens to some water animals that are trapped in warm water areas?

4. Predict what will happen to a fish's activity level if you were to cool the water slowly. If time allows, set up and perform.

	Breathing Activity	Overall Activity
Room Temp. ____ºC	1.	
	2.	
	3.	
	Avg.	
Heated Water 35ºC	1.	
	2.	
	3.	
	Avg.	

Observing Caddisfly Larvae as they Build their Homes.

Materials
Caddisfly larvae (preferably trichopteron larvae)
Culture tank or an aquarium that has air bubbling in it
Plant material (duckweed, elodea, and green algae) from stream site
Diatoms (also from stream site)
Wood, leaf, and stem fragments
Sand and silt particles
Pine needle parts
Man-made materials (wax paper, polythylene, and aluminum foil)

Procedure:

1. Keep the water at room temperature. Place the caddisfly larvae in the prepared culture tank or aquarium that is aerated.
2. If a caddisfly larva is already in its case, then carefully eject the larva from the case by pressing a blunt object through the closed end of the case. Watch the larva. Did the larva find and return to its own case?

3. If the caddisfly larva is by itself, place it in the tank and watch it build its own case.
What materials did it use to build its case?
What size of materials did it use to build its case?

APPENDIX D
Data Sheets

SAMPLE DATA SHEET FOR WATER MONITORING

Site: ______________________________ Date: _______________ Time: ___________

% Cloud Cover: _____________________________

Centimeters of Rain Within Past 49 Hours: ________

Air Temperature: __________ °C Water Temperature: __________ °C

pH: ________ Conductivity: __________________

Dissolved Oxygen (D.O.):
Sample 1: _______ mg/L Sample 2: _______ mg/L Sample 3: _______ mg/L
Average D.O.: _______ mg/L

Bottom Type of Stream: _____________________________________

Velocity: _________________ m/sec

Stream Width (meters): ______________

Stream Depth at 50cm intervals:

Pt. A.				Pt. B.			
1. ____	9. ____	17. ____	25. ____	1. ____	9. ____	17. ____	25. ____
2. ____	10. ____	18. ____	26. ____	2. ____	10. ____	18. ____	26. ____
3. ____	11. ____	19. ____	27. ____	3. ____	11. ____	19. ____	27. ____
4. ____	12. ____	20. ____	28. ____	4. ____	12. ____	20. ____	28. ____
5. ____	13. ____	21. ____	29. ____	5. ____	13. ____	21. ____	29. ____
6. ____	14. ____	22. ____	30. ____	6. ____	14. ____	22. ____	30. ____
7. ____	15. ____	23. ____	31. ____	7. ____	15. ____	23. ____	31. ____
8. ____	16. ____	24. ____	32. ____	8. ____	16. ____	24. ____	32. ____

Stream Flow: Pt. A ___________ cu. m/sec. Pt. B. ____________ cu. m/sec.

Suspended Solids: _____________mg/L Dissolved Solids: ______________mg/L

Fecal Coliform: #/0.1ml ___________
#/3m1 ___________
#/10ml ___________

Total Coliform: #/0.1ml ___________
#/3ml ___________
#/10ml ___________

Biotic Index: _________________________
# of Class 1 Organisms: ________ # of Class 2 Organisms: ________ # of Class 3 Organisms: ________

STREAM STUDY DATA SHEET

Group # ____ Names: ____

Date: _______________ Time: _______ AM _________ PM Site # ___________

Weather Conditions: ________________________________ Air Temp.: _______°

Site Description: ____

Water Temp.: ______° pH: ____________ Dissolved Oxygen: ___________ mg/L

Stream Depth

(for average calculation divide the total depth by 3 to get the average depth)

.5 meters from near bank: _________ meters
middle of stream: _________ meters
.5 meters from far bank: _________ meters
Total: _________ meters/3 = _________ average depth in meters.

Stream Width: _________ meters

Rate of Flow Calculation

(divide the meters by seconds to get meters per second)

distance: _________ meters divided by time: _________ seconds = _________ meters/second.

Rate of Flow (velocity) = _________ meters/second

BIOTIC LIFE

Floral (Plants)

________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________

Fauna (Animals)

________________________________ ________________________________
________________________________ ________________________________
________________________________ ________________________________

Comments or Drawings:

STREAM SITE DATA SHEET

SITE	A Headwaters	B Small Riffle	C Little Pool	D Large Pool	E Large Riffle
Bottom type					
Rate of flow					
Dissolved oxygen					
Temperature					
Kinds and number					
Total number					

Questions for Comparing the Stream Study and Stream Site Data Sheets

1. At which site was the temperature the highest? ____________________
2. At which site was the temperature the lowest? ____________________
3. At which site was the rate of flow the highest? ____________________
4. At which site was the rate of flow the lowest? ____________________
5. At which site was the dissolved oxygen the highest? ____________________
6. At which site was the dissolved oxygen the lowest? ____________________
7. Use the abiotic factors in 1-6 to explain the difference in the number of critters found in each site.

8. Which of the following factors (temperature, dissolved oxygen, and rate of flow) do you think caused the greatest difference in the number of critters at each site? Why?

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