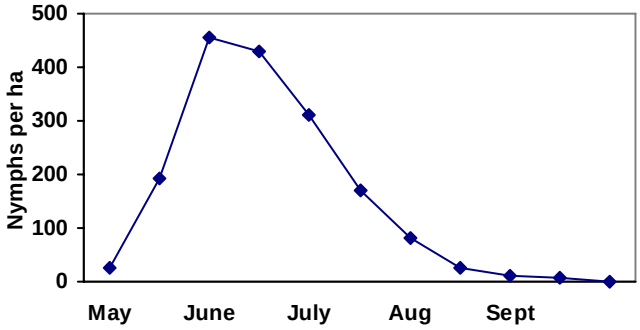
TICK BITE PREVENTION
&
THE USE OF INSECT REPELLENTS

Kirby C. Stafford III, PhD (Revised June 2005)
The Connecticut Agricultural Experiment Station, 123 Huntington St.-Box 1106, New Haven, CT 06504
(203) 974-8485, Web site: http://www.caes.state.ct.us

Introduction

The prevention of tick bites and the prompt detection and removal of attached ticks can reduce the chance of tick-associated disease. The pathogens that cause Lyme disease, human babesiosis, and human granulocytic anaplasmosis (formerly known as ehrlichiosis) are spread by the bite of the blacklegged tick, *Ixodes scapularis* (commonly called the deer tick). The American dog tick, *Dermacentor variabilis*, transmits the agents of Rocky Mountain spotted fever and tularemia, and can cause tick paralysis. Additional information on ticks and tick-borne infections is available from the Experiment Station fact sheets on *Tick-Associated Diseases*, *Ticks*, *Managing Ticks on Your Property*, the *American Dog Tick* and the Tick Management Handbook.



All active stages (larva, nymph and adult) of the blacklegged tick will feed on people and pets. Each stage of a tick feeds only once and slowly; requiring several days to ingest the blood.

Most Lyme disease cases are associated with the bite of the nymphal stage of *I. scapularis*. Nymphs are small (about the size of a pinhead), difficult to spot, and are active during the late spring and summer months when most people are outdoors (see graph of relative activity). Adults of *I. scapularis* are associated with fewer cases of Lyme disease. Adult ticks are larger, easier to spot, and are active in the fall, warmer days in the winter, and in the spring when outdoor activity is more limited. Blood engorged female *I. scapularis* may be confused in the spring with the American dog tick. Only the adult stage of the American dog tick, which feeds on people and pets, is active from April through August.

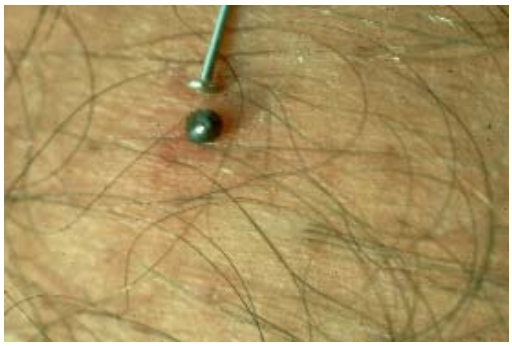
Dress appropriately and check for ticks . . .

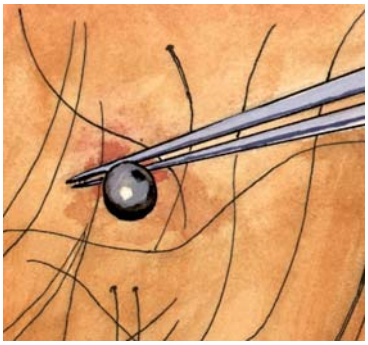
Ticks do not jump, fly or drop from trees, but grasp passing hosts from the leaf litter, tips of grass, etc. Most ticks are probably picked up on the lower legs and then crawl up the body seeking a place to feed. Adult *I. scapularis* will seek a host higher in the vegetation (i.e., shrub layer) as deer are the primary host. Wear light-colored clothing with the pants tucked into socks. Repellents can substantially increase the level of protection. On returning home, remove and wash and dry the clothing. Many ticks can survive a warm or hot water wash, but cannot withstand 1 hour in a hot dryer. Carefully inspect the body and quickly remove any attached ticks. Tick bites are usually painless and, consequently, many people may be unaware that ticks are or have been attached. Also, carefully inspect children and pets. As an age group, children have a higher rate of reported Lyme disease than many adults. Ticks may attach anywhere on the body (see figure next page). Pets can bring ticks into the home, resulting in a tick bite without the person being outdoors. A tick bite does not necessarily mean a person will develop Lyme disease (see risk of transmission). Most cases of Lyme disease result from an undetected tick and about 75% of ticks are acquired in activities around the home.

Photographs courtesy Pfizer Central Research.

Proportion of *Ixodes scapularis* (A) and *Dermacentor variabilis* (B) submitted to the Connecticut Agricultural Experiment Station recovered from various regions of the body. While ticks were recovered anywhere on the body, the distribution of the blacklegged tick was more uniform, while most American dog ticks were removed from the head and neck region. However, over a third of *I. scapularis* were from the legs and arms and another third were from the back up through the shoulders, neck and head.

Remove ticks promptly . . .

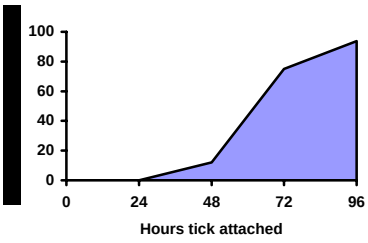




The mouthparts of a tick consist of a pair chelicerae and central hypostome.

Use thin-tipped tweezers or forceps to grasp the tick as close to the skin surface as possible. Pull the tick straight upward (see illustration) with steady even pressure. This should remove the tick with the mouthparts intact. If the mouthparts break off, it will not affect the chance of getting Lyme disease. Disinfect the area; a topical antibiotic may also be applied. Save the tick for identification and evidence of tick bite. A dead tick can be saved dry in a small sealable bag or vial, particularly if it is to be tested for spirochetes by DNA techniques (if available). Live ticks can be quickly tested by antibody staining methods and they can be kept alive with a few blades of grass to provide some humidity (if available). Note the site and date of the bite. Other methods of tick removal (e.g. petroleum jelly to suffocate the tick) are not effective. Use of heat from matches to make the tick back out or gasoline or other chemicals are unacceptable. Watch for signs and symptoms of Lyme disease. Although an average of only 20% of the nymphs in Connecticut is infected with *B. burgdorferi*, this can vary from about 10-30% in any given year or location.

Risk of Transmission



The risk of transmission of *B. burgdorferi* from an infected feeding nymph of *I. scapularis* increases dramatically after 48 hours of attachment. Early removal of an attached tick will reduce the chance of Lyme disease. During the first 24 hours of tick attachment, there is no transmission. By 48 hours of feeding, the transmission rate in one study was only 12.5% and then by 72 hours the transmission rate increases to 75%. Transmission by an infected tick is almost 100% after 4 days and full engorgement. Studies on the prophylactic use of antibiotics upon a detected tick bite found that the risk of Lyme disease in the placebo groups was around 5% or less.

Topically Applied Insect Repellents

Insect (and tick) repellents applied to skin and/or clothing can be broadly grouped as synthetic-chemical or botanical chemical-based compounds**.** Repellents have been generally been evaluated against mosquitoes and there are established protocols for mosquito testing. The duration of protection in trials with human volunteers can vary greatly from individual to individual. Data for efficacy against ticks is more limited. There are no well established testing protocols and techniques have varied depending upon the study. The effectiveness of a repellent against mosquitoes does not indicate how effective a product will be against ticks, but may provide a broad indication of repellency potential. Repellency for a given compound at a given concentration is generally, but not always less against ticks than mosquitoes, which are generally repelled at lower application rates than ticks. An ideal repellent would provide complete protection for several hours under different environmental conditions, protect against all biting arthropods, be non-toxic, non-irritating, be harmless to clothing, be cosmetically acceptable with no unpleasant odor or oily feel to the skin, be easy to apply and inexpensive.

Insect repellents include:

- DEET (N,N-diethyl-m-toluamide, also known as N,N-diethyl-3-methylbenzamide).
- IR3535 (Ethyl Butylacetylaminopropionate or 3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester).
- Picaridin (1-piperidinecarboxylic acid, 2-(2-hydroxy)ethyl)-, 1-methylpropylester).
- MGK-326 (di-n-propyl isocinchomeronate), used in conjunction with DEET in composite formulation.
- MGK-264 (N-octyl-bicycloheptene dicarboximide), used in conjunction with DEET in composite formulation.
- Oil of Lemon Eucalyptus (p-Mentane-3,8-diol).
- Citronella, Soybean, Peppermint, and other plant essential oils.

List of insect repellents by active compound (more detail on ingredients and use is provided in the text).

Active Ingredient	Brands	Manufacturer or Distributor
DEET (5-100%)	Many brand names, formulations, and concentrations available from several manufacturers or distributors (~230 products). *Off, Cutter, Repel, Muskol, Ben's, Sawyer, BugX* – major drug store chains also carry their own labels.	Off, S. C. Johnson & Sons, Inc. Cutter, Spectrum Brands, Inc. Repel, Spectrum Brands, Inc. Ben's, Natrapel Inc. Sawyer, Sawyer Products
DEET controlled release formulations	3M Ultrathon™ (polymer-based) Sawyer Controlled Release (microencapsulated)	3M Company Sawyer Products
IR3535 (7.5%)	Skin-So-Soft Bug Guard Plus IR3535® (spray) Skin-So-Soft Bug Guard Plus IR3535® (lotion w/ sunblock)	Avon Products, Inc.
Picaridin (Bayrepel® or KBR3023)	Cutter® Advanced (Bayrepel® in Europe) (Autan® in Europe)	Spectrum Brands, Inc. Bayer Chemicals S. C. Johnson & Sons, Inc.
Permethrin (0.5%) For use on clothing only.	Coulston's Duranon® Tick Repellent Repel® Permanone Sawyer® Clothing Tick Repellent Cutter® Outdoorsman Gear Guard 3M™ Clothing and Gear Insect Repellent No Stinkin' Ticks™	Spectrum Brands, Inc. Spectrum Brands, Inc. Sawyer Products United Industries Corporation 3M Company Robinson Laboratories, Inc.
MGK-326	A repellent used with DEET in composite repellent formulations (also contains MGK-264). Example: Cutter® Tick Defense™	Sawyer Products Spectrum Brands, Inc.
MGK-264	A mosquito repellent and synergist used with DEET in composite repellent formulations (also contains R-326). Example: Cutter® Tick Defense™	Sawyer Products, Inc. Spectrum Brands, Inc.
Oil of Lemon Eucalyptus	Off! Botanical Repel® Lemon Eucalyptus Insect Repellent	S.C. Johnson and Sons, Inc. Spectrum Brands, Inc.
Citronella oil	Natrapel (Oil citronella only) Green Ban for People (Oil citronella, peppermint, others) Buzz Away (Oil citronella, peppermint, others) Herbal Armor (microencapsulated oil citronella, peppermint, others)	Tender Corp. Mulgum Hollow Farm Quantum Inc. All Terrain Co.
Soybean oil	Bite Blocker® Herbal Repellent (not labeled for ticks, also contains coconut and geranium oils)	HOMS, LLC.

Mention of a repellent product does not constitute an endorsement by the CT Agricultural Experiment Station

DEET: The primary active ingredient in most insect/tick repellents today is DEET, the most effective, broad-spectrum repellent ever discovered. The U.S. Environmental Protection Agency (EPA) estimates that over one-third of the U.S. population will use a DEET-based product. There are approximately 230 products containing DEET registered with the EPA (e.g. *Cutter, Off, Repel, Muskol, Ben's, Sawyer,3M Ultrathon, and many others*). Products range in concentration from less than 5% to 100% DEET and are available as an aerosol can, pump spray bottle, stick, lotion, cream, or towelette for application to skin or clothing. All active ingredients and their concentrations are listed on the product label. DEET is the sole active ingredient in most commercial products, but composite products contain DEET plus repellents MGK-236 and MGK-264 to enhance repellency against biting flies.

DEET is effective for one to several hours and must be reapplied periodically. The effectiveness of DEET on the skin is influenced by the concentration of DEET, absorption through the skin, evaporation, sweating, air temperature, wind, and abrasion of the treated surface by rubbing or washing. Higher concentrations generally provide longer protection, but increasing the concentration does not provide a proportional increase in protection time with duration of protection leveling off at a concentration of 50%. Most commercial formulations contain 40% DEET or less, although a few are available ranging up to 100% DEET. A recent study comparing the efficacy of insect repellents against bites of the mosquito *Aedes aegypti* found that a 23.8% DEET formulation provided an average of 5 hours of complete protection, while 6.65% DEET provided slightly under 2 hours of protection. The carrier in DEET may be alcohol, a polymer, lotion, or water-based. Several extended-release DEET formulations have been developed which increase protection time at a reduced concentration of repellent and may decrease skin absorption. Extended duration products include *3M Ultrathon* (DEET incased in a polymer) and *Sawyer's Controlled Release* (a protein sub-micron encapsulation of DEET).

DEET and ticks: DEET will repel ticks and decrease the chances of tick bite, but depending upon the concentration, it may not provide total protection against *I. scapularis*. Little is known about the effectiveness of different concentrations of DEET against *I. scapularis*. Concentrations of DEET that might prevent tick attachment may not deter a tick from walking across the skin to unexposed and untreated areas. When applied to clothes, 30% and 20% DEET was found to be 92% and 86% effective against *I. scapularis*, respectively, but skin applications were reported to be only 75 to 87% effective against crawling ticks in a second study. For blacklegged ticks, DEET concentrations around 30 to 40% probably should be used, although the effectiveness of higher (>50%) and lower (<20%) concentrations against *I. scapularis* needs to be examined more closely. One towelette product contains 52.25% DEET. When applying a repellent against ticks, particular attention should be given to the shoe tops, socks, and lower portion of pants.

Composite DEET Repellents with MGK-326 and MGK-264: There are no repellents registered for use in the United States that contain MGK Repellent 326 (Di-n-propyl isocinchomeronate) or MGK Repellent 264 (n-Octyl bicycloheptene dicarboximide) as the sole active ingredient. These compounds are used together with DEET in composite formulations in repellents for human use. MGK-326 is supposed to be particularly effective against biting flies. MGK-264 is used as a synergist and is supposed to enhance the repellency of DEET. Many brands of composite repellents are available as sprays, lotions, or liquids, and are labeled for use against biting flies (including horse flies, deer flies, stable flies, black flies, no-see-ums, gnats, and mosquitoes), fleas, chiggers, and ticks. The EPA ruled through a Reregistration Eligibility Decision (RED) that MGK-326 poses no unreasonable adverse effect on human health when properly used. MGK-326 was classified as a probable human carcinogen in 1993. To mitigate risk, the EPA has limited total production and use of MGK-326 and set a maximum concentration of 2.5% in repellent products. As directed on the label, no more than 3 applications per day of MGK-326 are allowed on children twelve and under to limit overexposure in young children. No data were found to indicate that these composite repellents would be more effective against ticks than the same concentration of DEET alone.

Permethrin*:* Repellents containing permethrin are for use only on clothing or other fabrics such as mosquito netting or tents. A synthetic pyrethroid insecticide rather than a traditional repellent, permethrin works primarily by killing ticks on contact with the clothes, although it also has some repellency. It can provide very high levels of protection against ticks (and chiggers and mosquitoes). Several products contain 0.5% permethrin (e.g., *Duranon Tick Repellent, Repel Permanone, Cutter Outdoorsman Gear Guard, Sawyer Clothing Tick Repellent, 3M Clothing and Gear Insect Repellent, No Stinkin' Ticks*). Products are formulated as an aerosol spray or pump with a concentration of 0.5% and distributed mainly in lawn and garden centers or sports and camping stores. It will provide at least 2 weeks of protection with one treatment of the clothing as the spray will bind to the fabric and last through several washings. The clothing should be laundered before retreating. For proper application, the products are applied per label directions to clothing in a well-ventilated outdoor area and allowed to dry for 2 hours (4 hours with high humidity). Follow precautions on the label. Wash thoroughly with soap and water after handling. Permethrin has low mammalian toxicity, is poorly absorbed through the skin and is rapidly inactivated by the body. Skin reactions have been uncommon. Nevertheless, avoid contact with face, eyes or skin. For additional protection against mosquitoes and ticks, these products may be used in conjunction with an insect repellent labeled for use on skin.

IR3535®: Classified by the EPA as a biopesticide (it is structurally very similar to the amino acid B-alanine), this synthetic compound has been used as an insect repellent in Europe for 20 years with no notable adverse effects and was

approved for use in the United States in 1999. Several formulated products with IR3535, including a spray, an aerosol, a towelette, and a lotion and spray with sunblock (SPF30 & SPF15), are currently available in the United States (e.g., Skin-So-Soft Bug Guard Plus Insect Repellent with IR3535 in several formulations, with IR3535 at 7.5, 15, and 20.05%). They are labeled for use against deer ticks, mosquitoes, and several other biting flies. IR3535 provided substantially less mean complete protection (22.9 minutes) against the mosquito *A. aegypti* than a low concentration (4.75%) of DEET (88.4 minutes) in one study. Other studies have found IR3535 protected against mosquitoes for 0-3 hours.

The EPA recognizes general use of IR3535 as safe for both children and adults. Toxicity of IR3535 is very low. It is not a skin irritant or sensitizer, but IR3535 is a strong eye irritant. According to the Avon product label, adults should apply the spray product to children under 10 years of age.

IR3535® and ticks: There is little published information on the efficacy of IR3535® against the blacklegged tick and other ticks. Industry-sponsored evaluations of IR3535 against *I. scapularis* suggest that 15% IR3535 is as effective as 30% DEET and 30% IR3535 is as effective as 60% DEET against the blacklegged tick. After 2 hours, >85% repellency was observed with both 15% IR3535 and 60% DEET on treated human fingers. Another study showed Avon Bug Guard Plus with Sunblock (7.5% IR2535) lotion provided protection against blacklegged ticks for about 3 hours.

Picaridin (Bayrepel®, KBR2030): The Centers for Disease Control and Prevention (CDC) recently added a Picaridin-based insect repellent and oil of lemon eucalyptus-based repellent (see below) to DEET as recommended repellents for the prevention of mosquito bites. Several published studies of the use of picaridin repellents against mosquitoes has shown the compound to be as effective or slightly more effective than similar concentrations of DEET, depending on the mosquito species. It is claimed to have more pleasant cosmetic properties than DEET. The chemical name for picaridin is 1-piperidinecarboxylic acid, 2-(2-hydroxyethyl)-, 1-methylpropyl ester. It is also known as KBR2030 or Bayrepel® (a trademark of Bayer AG) and has been available in Europe and Australia under the Autan® brand (S.C. Johnson and Sons, Inc.) since 1988. There is one brand, Cutter® Advanced, currently available in the United States at two concentrations (5.75 and 7%). S.C. Johnson and Sons will also be providing a picaridin-based repellent. Cutter Advanced is labeled for protection against biting flies, chiggers, fleas, gnats, mosquitoes and no-see-ums, but is <u>not</u> labeled for use against ticks. One study against nymphs of an African *Amblyomma* tick species found that 20% KBR2030 was much less effective than 20% DEET. Unlike DEET, this repellent has no adverse affect on plastics and synthetics.

Botanical or "Herbal"-based Repellents: Botanical, herbal or natural-based repellents include one or several plant essential oils. Some new products are refinements of these essential oils or synthetic versions of the active ingredient in the natural oil. These oils are considered safe by the EPA at the low concentrations used, but provide a limited duration of protection against mosquitoes (< 3 hours). There is virtually no published data on the efficacy of plant-based repellents against ticks and most are not labeled for use against ticks. Citronella is often the principal and sometimes only active ingredient in many plant-based insect repellents. Oil of lemon eucalyptus, soybean oil or geraniol are the sole active ingredients in some products. Available in several brands or formulations, oil of lemon eucalyptus provides protection against mosquitoes similar to low concentrations of DEET. Two products containing oil of eucalyptus or its primary compound provided the most protection against mosquitoes with protection ranging from 60 to 217 minutes, better than 7-15% DEET. The compound p-menthane-3,8-diol occurs naturally in the oil of the lemon eucalyptus plant. It was originally isolated from waste distillate of lemon eucalyptus oil extract, but the synthetic compound is used. The EPA recognizes general use of p-Mentane-3,8-diol as safe for both children and adults as the toxicity of p-Mentane-3,8-diol is very low. However, the label states it should not be used on children under the age of three. Although at least one brand is labeled for use against ticks, no published data were found to indicate how effective this repellent compound is against ticks. A 2% soybean oil-based repellent has been reported to provide an average of 1.5 hours of protection against mosquito bite, while other botanical repellents tested provided only short-term protection with a mean protection time of only 3 to 20 minutes. There are no published data on repellency against mosquitoes for many of the other oils incorporated into repellent products. Other essential oils used in these natural-product based repellents include peppermint, lemongrass, lavender, cedar, canola, rosemary, pennyroyal, geranium and cajeput among others. In summary, most plant-derived repellents are not labeled for ticks and are unlikely to provide much protection against ticks.

Other Repellent Options

Avon's moisturizing Skin-So-Soft bath oil has been widely touted as a mosquito repellent, but provides less than 10-30 minutes of protection against mosquitoes and is unlikely to offer any protection against ticks. Ingested compounds like garlic and vitamin B1 and ultrasonic sound devices do not repel mosquitoes and probably do not repel ticks. Wrist-bands impregnated with either DEET or citronella provided no protection against mosquitoes and would not protect against ticks either. Protection is provided only around where the repellent is actually applied.

Safe Use of DEET and Other Repellents*:* The EPA completed a review of DEET as part of evaluating pesticides for reregistration in 1998 and concluded that normal use of DEET does not present a health concern to the general population. The EPA established new labeling requirements for directions, precautions, and claims for the safe use of deet and child safe claims for low concentration DEET products are no longer allowed. After 40 years of use and an estimated 8

billion applications, DEET has a remarkable safety record. The incidence of adverse reactions is extremely low with fewer than 50 cases of serious effects documented in the medical literature since 1960. However, a few allergic, toxic and neurological reactions to DEET have been reported in the medical literature. Repeated applications have occasionally produced tingling, mild irritation or contact dermatitis. Some individuals may be particularly sensitive to chemicals. Toxic encephalopathic reactions are rare, but have occurred with dermal applications, particularly with children. The reported cases involved high concentrations of DEET and over application of product contrary to label directions. Therefore, it is prudent to minimize the use of high concentrations on the skin and follow the directions and precautions given on the repellent label. The American Academy of Pediatrics recommends 10% or less DEET in repellents used on children. People with certain skin conditions should be cautious about the use of DEET. Apply DEET sparingly to exposed skin, and spray on clothing when possible. DEET is a plasticizer and will harm some synthetic fabrics (rayon and spandex), plastics (watch crystals and eyeglass frames), and car and furniture finishes. If you suspect a reaction to DEET (or any other repellent), stop using the product, wash the treated skin, and call the poison control center (CT 1-800-343-2722). Medical and safety information about the active ingredients in an insect repellent is available from:

National Pesticide Information Center (NPIC) by telephone (1-800-858-7378) from 6:30 a.m. to 4:30 p.m. Pacific Standard Time or 9:30 a.m. to 7:30 p.m. Eastern Standard Time. Additional information is available at their web site (http://npic.orst.edu/).

EPA recommends the following precautions when using insect repellents (from EPA web site):

- Follow the directions and precautions given on the repellent label.
- Apply repellents only to exposed skin and/or clothing (as directed on the product label). Do not use under clothing.
- Never use repellents over cuts, wounds, or irritated skin.
- Do not apply to eyes and mouth, and apply sparingly around ears. When using sprays do not spray directly onto face; spray on hands first and then apply to face.
- Do not allow children to handle the products, and do not apply to children's hands. When using on children, apply to your own hands and then put it on the child.
- Do not spray in enclosed areas. Avoid breathing a repellent spray, and do not use it near food.
- Use just enough repellent to cover exposed skin and/or clothing. Heavy application and saturation is generally unnecessary for effectiveness; if biting insects do not respond to a thin film of repellent, then apply a bit more.
- After returning indoors, wash treated skin with soap and water or bathe. This is particularly important when repellents are used repeatedly in a day or on consecutive days. Also, wash treated clothing before wearing it again. If you suspect that you or your child is reacting to an insect repellent, discontinue use, wash treated skin, and then call your local poison control center. If/when you go to a doctor, take the repellent with you.
- Get specific medical information about the active ingredients in repellents and other pesticides by calling the National Pesticide Information Center (NPIC) at 1-800-858-7378. NPIC operates from 6:30 a.m. to 4:30 p.m. (Pacific Time),9:30 a.m. to 7:30 p.m. (Eastern Time), 7 days a week. The NPIC Web site is: http://npic.orst.edu/

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