Based upon outcomes observed during the many years of the Arrow Lethality Studies, I have several criteria for what makes a really good broadhead. They are: (1) the blade must have reasonable metal thickness; (2) that it be of very good quality steel; (3) that it neither bend nor break when hard bone is hit; (4) that it have a Rockwell scale hardness from fifty-two to fifty-seven; (5) that the steel from which it is made will tend to break before taking a bend; (6) that it have a long and narrow shape (high mechanical advantage); (7) that the ferrule taper is long, and fades very smoothly into the blade; (8) that there are no abrupt junctures anywhere on the head, and (9) that the blades have a straight taper cutting edge.

For each of these criteria I have a specific reason for delineating it. These reasons are a direct result of information from the Lethality Studies. Let’s look at each individually.

Metal Thickness: As one of the criteria is for a blade of long and narrow profile; increased metal thickness is necessary to maintain rigidity in the blade. The thickness also increases tip strength, but having reasonable metal thickness in a broadhead is among the criteria for more reasons than just added strength. Though I have found no way to quantify it, the outcome data is highly suggestive that blade thickness; up to a point; aids in splitting bone.

There is more to the bone-cutting and bone-splitting qualities of a broadhead’s edge than angle at which it is sharpened. Increased blade thickness allows a longer physical length of the edge’s bevel. The edge-bevel of a broadhead is a simple machine; an inclined plane; which can multiply the work done with the force applied. The longer that plane in relation to its sharpening angle the deeper into a ‘cut’ this mechanical advantage can be used. In theory, this could be an important factor in splitting bones. Study data suggest that it is. Blade thickness can also affect a broadhead’s ability to split bone in other ways, which are better covered when we discuss mechanical advantage and ferrule profiles, further along.

Steel Quality: Quality of the steel as a requirement needs little explanation. Steels of poor quality don’t hold up well to impact. A great performing broadhead will neither bend nor break with impact on any tissues. A broadhead which becomes damaged at any point during penetration results in a dramatic loss in penetration. The uneven resistance forces created when a broadhead bends causes the arrow’s shaft to ‘torque’, and the arrow’s path of penetration to deviate. This causes the shaft to flex, which substantially increases shaft drag.

Even with quality steels, the tempered hardness needs to be sufficient for the broadhead's edge to remain sharp throughout the entire course of penetration. The metal must be sufficiently hard to prevent the rolling of an edge on hard bone impact. At the same time the steel needs to be soft enough to be sharpened, or re-sharpened, by simple field methods.

I have found that broadheads having Rockwell hardness less than R 49 do not reliably maintain sharpness throughout the entire course of penetration. The harder the steel, the longer it will hold its edge, but anything much over R 57 becomes difficult to sharpen *readily* by common field techniques. My preference is for steels as hard as I can re-sharpen in the field with reasonable efforts; about R 52-57.

High carbon steels are my preference, but have encountered some of the high chrome and stainless steels which are also outstanding in edge holding ability. The SilverFlame broadhead is an excellent example; the blade is of 440B stainless steel, hardened to R55-R57, and supplied with a hollow-ground and stropped edge, ready for use. They have the sharpest factory supplied edge I've seen on any broadhead, including the replaceable blade broadheads.

<u>Breaking before bending</u>: If a broadhead reaches a point in resistance force where it *must* either bend or break, I want the head to break. The studies show that a head which breaks will have *less* negative impact upon arrow penetration than one which bends; breaking becomes the better of the two options, neither of which is desirable.

To achieve some impression of this structural feature of a broadhead, I frequently test their flexion and bending/breaking characteristics by clamping 1/4" to 1/2" of the broadhead's tip in a vice and applying lateral force until the broadhead bends or breaks. I then repeat the test, applying a torque force until the head bends or breaks. This flex-test is not used as a basis of evaluation of how it might perform on bone impacts, but only to get an impression of how the broadhead reacts to excess stress. Any broadhead has to give at a certain point of stress. Only the broadhead's performance on shots into real tissues is used as the criteria for evaluation of the true nature of its bending and breaking potential; during 'real world' application.

<u>Blade profile</u>: A broadhead having a long and narrow profile will have a higher mechanical advantage than a similar one; either shorter in length or wider in cut. The mechanical advantage of one's broadhead is one of the major factors influencing penetration; especially in heavy bone. Hunting

arrows carry a very low amount of force, relative to the task we ask it to perform; or task it *might* be asked to perform should the hit be less than perfect. *At every stage of developing the hunting arrow one should chose components maximizing the arrow's ability to perform as much 'work' as possible with whatever force it has available to it.*

Mechanical advantage is the improvement gained by use of a mechanism (machine) in transmitting force. It is the ratio of the *"applied force"* required to perform a given amount of "*useful work"*. In other words, broadhead design can multiply the force of the arrow, increasing the amount of work it can achieve with whatever force the arrow carries at the instant of impact.

Not all broadheads offer an equal mechanical advantage. As with any inclined plane, the longer the slope of the plane in relation to the rise of the plane, the higher will be the mechanical advantage. A long and narrow single-blade (2 cutting edges) broadhead will have a higher mechanical advantage than one of equal length and width, but having more blades. Also, as the profile of a broadhead's blade(s) becomes shorter and/or wider the mechanical advantage becomes less.

<u>Ferrule profile and fade-in</u>: Ideally the broadhead's ferrule will also be long. As with broadhead blade design, the longer the taper of the broadhead's ferule in relation to its width (diameter) the higher its mechanical advantage will be. The higher the mechanical advantage of the ferrule, the less it detracts from the blade's mechanical advantage.

A combination of high mechanical advantage in both the blade's profile and the ferrule's profile can increase the bone splitting ability of a broadhead.

If one has ever done much splitting of firewood with mallet and wedges of both standard and compound wedge design this advantage will be well know to them. The experienced wood splitter, if he has much ash or hickory to split, reaches for his mallet and compound splitting wedge; it saves a lot of energy! Incidentally, these woods have interlocking fibers, which is one reason they are so difficult to break apart. Bones also have an interlocking matrix configuration.

Wedge: compound wedge & Companion BH Photo; drawing? Glossary?

It is in respect to this compound wedge effect that greater blade thickness also appears to offer some advantage. Of course the location of the ferrule's fade-out; in relation to the blade's length, and the position of the broadhead's tip;

is also an influencing factor. A blade of greater thickness provides for both a longer tip bevel and a less abrupt rise along the face of the broadhead, as it steps progressively up to terminal end of the ferrule’s fade-out. (The “face” of a broadhead is the surface between the two cutting edges.) Any abrupt rise in the contour of a broadhead results in a profile which lowers the broadhead's *mechanical advantage*.

Any abrupt changes in the overall profile of the broadhead, or the arrow, results in a ‘spike’ in resistance force as the arrow penetrates tissues. An arrow having any given impact-force must be met by an equal amount of resistance before its forward motion comes to a stop; but an arrow must meet any ‘spike’ in resistance through utilization of a portion of its total force.

A resistance spike occurs over a short period of time. It rapidly reduces the arrow’s remaining force. After encountering a resistance spike, and being required to use up a significant part of its available force, the arrow will be stopped in a shorter period of time by the ‘normal’ tissue resistance forces. The result will be a lower total “impulse of force” being applied by the arrow upon the tissues. Overall arrow penetration decreases. (Understanding impulse of force, and its implications in arrow penetration, is essential to the understanding of terminal arrow performance. More discussion of this topic will follow when we discuss arrow mass weight.)

Just as for the broadhead’s edge, overall blade profile represents a simple machine; an inclined plane. When cut width and blade length are compared, a blade profile which features a straight taper of the blades offers a higher mechanical advantage than blades which are either convex or concave in shape. Convex blades feature a greater degree of rise in comparison to the distance traveled. Concave blades begin with a higher mechanical advantage than a straight taper blade, but this abruptly changes as the concave edge sweeps outwards. This abrupt rise in a concave blade’s profile results in a higher spike in resistance force as this abrupt rise passes through either bone or soft tissue.

For any given broadhead length and cut-width, a straight taper blade and ferrule will provide the highest possible mechanical advantage. It becomes a series of straight inclined planes; and permits the broadhead to do any given amount of work with the least possible expenditure of energy. That is why handicap access ramps, for wheelchair use, have straight inclined planes. If convex or concave ramps allowed the elevation to be achieved with less effort, one can rest assured these ramps would be convex or concave!

***** Will Need Updating with blood-trail test data here; when testing is completed *****

Broadhead tip design: Broadhead tip design, and its effect on performance, is an area of broadhead design the bowhunter should give thought to, but few seem to do so. Broadheads come in a wide verity of tip types and profiles. Broadhead tips are subdivided into two broad categories: cut-on-impact (COI) tips and "bone-breaker' tips.

'Bone breaker' tips, common on many replaceable-blade broadheads, are usually a round or conical-spire; extending some greater-or-lesser degree in front of the cutting blade's forward, leading edge. The spire may terminate in either a needle-tip cone or be faceted-off to form a series of sloping edges; three or four in number; which meet at the tip, forming a three or four sided pyramid.

Cut-on-impact tips are as described; they have sharpened slicing-edges along the blade's surface; right up to the tip. They are designed to slice through skin and soft tissue from the instant of impact; rather than having to 'punch' their way through, as the bone-breaker tips do. COI tips use up less of the arrow's impact-force getting through skin and muscle, and arrive at bones with more retained momentum.

The COI tip will have a 'profile'; which describes the shape of the main blade and/or the tip section of the main blade. They come with a wide verity of profiles: needle-tips; round tips; flat tips; chisel tips; arch tips; concave tips (an ancient medieval design, still popular in some parts of the world); and "Tanto" tips (having a triangular profile). To this list one might also add the flat tip, which is not a true COI design; being merely squared off and not sharpened.

There are also the tips of three-bladed broadheads to consider. These often come to a COI needle-tip. It is common for bowhunters to reshape this tip, forming a three sided diamond, or pyramid tip profile. These reshaped tips have many of the same bone-penetration characteristics as a similarly shaped bone-breaker tip would have. The one difference is that the cutting blades approach much closer to the tip than they would on the typical replaceable-blade broadhead having a bone-breaker tip.

Extensive testing during the Lethality Studies has shown that bone-breaker tips readily stick into bone, but are not very efficient at splitting bone sufficiently to facilitate passage of the main cutting blade(s); especially in heavier bone. This applies regardless of the design of the bone-breaker spire; conical or pyramidal.

The Study also shows that most COI broadheads having needle tips are very vulnerable to bending at the tip. It is not merely due to the tip being ‘small’ or ‘thin’ that this occurs. There are other factors at work.

Many feel that it is merely the thinness and smallness of the needle-tip that causes it to bend; much as would occur if one shot a steel plate. Bone is hard, but it is not steel. Conversely, many broadhead tips that stand up very well to impacts with very strong objects; rock, concrete and even steel-plate; often bend on impact with bone. What causes the difference?

All broadhead-tipped arrows show a marked tendency to ‘skid’ when impacting bone. *Very close* examination at the site of broadhead impact on bone virtually always reveals evidence the arrow has skidded on the bone’s surface; to a greater or lesser amount; before either penetrating the bone or slipping past it. In order to see these areas of arrow-skid one often has to *thoroughly* clean the bone; frequently requiring removing the periosteum, the thin layer of connective tissue which envelopes the bone; and any bone fragments broken away by the arrow.

The frequency of broadhead-skid when impacting bone should come as no surprise. Mother Nature designed bone to deflect blows. Examine a rib’s design and structure. Its outer surface is, truly, bone-hard. Beneath this is a softer inner-layer that easily gives-way when laterally-acting force; any force not absolutely perpendicular to the bone’s surface; is applied.

A rib’s shape is a ‘double radius arch’; it arches from top to bottom, and is also an arch in cross-section. The arch is among nature’s stronger load-bearing structural profiles; and is excellent for both supporting and diverting (redirecting) applied forces. These surfaces, and the bone’s structure, set ideal conditions for forcing objects attempting to penetrate to skid along the bone’s surface, rather than penetrate the bone. The bone’s hard and curved outer surface initiates the skid. If the tip breaks through the bone’s hard outer surface, biting into the softer inner-bone material, the softer bone flakes-away, denying a firm-purchase in the bone to the object. This facilitates the skid continuing along the bone’s arched surface(s).

It is during the phase of bone-skid that needle-tip broadheads most often suffer damage. If the broadhead’s main-blade is of softer steel, they often bend; if of very hard steel, they snap. Study data indicates that even a slightly bent broadhead tip results in an average penetration loss of 14%. That may not sound like a lot, but it means the difference between 10” and 11.4” of penetration; often enough to make the difference between a single and double lung hit on any sizable animal. If the force and angle of a hit requires that the broadhead’s tip must bend or break, it is preferable that it snap off. A broken tip causes less penetration loss than even a very slightly bent tip.

When a shot impacts bone at an anything other than an absolute perpendicular angle to the bone’s surface these slip-factors and forces come into play. The more obliquely the arrow impacts the bone’s surface, the greater the skipping-force will be. All broadheads eventually reach a bone-impact angle where they will be totally deflected away; skipping off the bone, failing penetrate it. The impact angle at which broadheads/arrows show a marked tendency to skip-off the bone, rather than penetrating it, I have named; the “broadhead skip-angle”. Even bullets from high-power hunting rifles deflect off very light bone when their skip-angle is exceeded.

Testing revealed that, once the skip angle is reached, there is roughly a 50% chance the arrow will skip-off rather than penetrate. Each broadhead design has a definite skip-angle, and these vary significantly. Skip-angle is a factor the bowhunter should consider when choosing either broadheads, or the shot he will take. There will be more discussions regarding skip-angle, with specific test results, shortly. For now, let’s concentrate on the broadhead’s tip.

One rarely bends the tip-end of a bone breaker tip but, as noted, this tip design performs poorly when it comes to actually breaking through the bone. Bone breaker tips do frequently bend, but most commonly at the position where they attach to the ferrule.

Since an arch is among the stronger structures, what about using an arch against the bone’s arch? Having an arched profile on the broadhead’s tip can be effective, but requires a fairly pronounced arch. The Deadhead has proven very strong, and its tip has never suffered damaged during bone impact in the Studies and; being one of the Study’s ‘benchmark’ broadheads it has been far more thoroughly tested than most others. The Deadhead’s tip is a very pronounced arch.

There is, however, a down-side. Most broadheads that come with a pronounced arch tip-profile generally are of a wide-cut verity with a convex cutting shape. This means a much over-all mechanical advantage for the broadhead. A pronounced arch profile can, however, be added onto most traditional-type broadheads. Arch on arch can also accentuate the skip-effect; which is not, as one will see shortly, *always* a bad thing; but sometimes is.

As close examination indicates that the arrow generally skids anyway, why not use a tip design that allows it to slip easily; a rounded tip? A rounded tip profile does, indeed skid more easily on the bone's surface than any other tip design. It is a profile which can easily be added to any broadhead having a flat main-blade. Single blade broadheads show a marked tendency to skid along the surface of a rib anyway; especially on obliquely-impacting shots. They often slip along the rib's surface until they find an intercostals space through which to enter the thorax.

The round tip-profile, however, also has a down-side; the same down-side as the arch. Though highly effective on rib-impact hits, round and arch tips require more force in order to actually penetrate a bone. Shots impacting squarely on a bone uses up a lot of impact-momentum forcing such tip-designs through the bone. When the arrow impacts a large flat-bone, such as the scapula, it has to penetrate the bone. Slipping past the bone is no longer an option. Here, at some point, the broadhead needs to bite into the bone, minimizing any skid tendency; and penetrate the bone with the minimum force-loss possible.

A focal-study to test differing COI tip designs was conducted. The broadheads used were Concords. They are a 155 gr. broadhead with long and narrow profile, having a 1.115" cut width edge length of 2.651". In earlier testing, both its main blade and needle tip had shown a tendency to bend frequently, especially with adverse angle bone-impact. Forty-two broadheads were used; six each of seven different tip profiles. Six retained the factory needle tip. Six each were modified to: flat (squared off at the tip); chisel-tip (squared off and sharpened to a cut-on-impact (COI) edge); COI arch-tip; COI round-tip; COI Tanto-tip and COI concave-tip.

Edges were double-bevel sharpened at 25 degrees, and all edges honed and stropped to a shaving edge. All were mounted on matching tapered hickory shafts. Finished arrow mass was matched within ± 7.5 grains. Average mass was 771 grains. To facilitate placement of impacts on the scapular flats, shooting was done at 10 yards. The bow used was a modern reflexed/deflexed 70# longbow.

Test subjects were two freshly culled buffalo; a young adult male and an adult female. The relatively low impact-force (for a buffalo-size animal) was chosen so most broadheads would be unlikely to penetrate the scapular flat. Three shots with each tip-design were fired into the scapular flats of each buffalo. Shots into the young male were fired broadside; with perpendicular bone impact. Shots into the adult female were fired quartering from the front at 40^0, giving an oblique bone-impact angle.

The following chart shows test results. Test numbers are low, but clear tendencies show. COI tips of round and Tanto profiles showed increased frequency of bone penetration, and a low frequency of damage, even on these softer broadheads. No broadhead with a flat, chisel or concave tip-profile penetrated the scapular flat. Needle tipped broadheads suffered a 100% tip-bend rate, with only one penetrating the scapula.

Broadhead Tip Design Test

N_{Total}=42

Test Broadheads: Modified Concord.

For all shots: Arrow Mass = 771 Gr. ± 7.5 gr.; Impact Momentum = 0.442; Impact KE = 28.48						
Six shots with each tip design: 3 shots, each tip design, at approx. 40^0 quartering from the front on an adult female Asian Buffalo; 3 shots, each tip design, from broadside on a young adult male Asian Buffalo.						
All Impacts: Scapular Flat Range: 10 yards.						
N=	**Tip Design**	**Number Broadheads Damaged**	**Number Pen. Scapular Flat**	**Average Penetration (Inches)**	**Range Of Penetration (Inches)**	**Median Penetration (Inches)**
6	Tanto	1	5	9.73	6.4 - 12.1	9.07
6	Round	2	4	7.63	5.0 - 10.1	7.75
6	Chisel	2	0	6.00	5.5 - 6.6	5.94
6	Arch	3	1	5.63	5.0 - 7.1	6.06
6	Concave	0	0	4.63	4.5 - 5.0	4.50
6	Needle	6	1	5.33	4.9 - 6.1	5.00
6	Flat	2	0	5.42	4.8 - 6.4	5.06

The Tanto tip did the best; both in durability, number of shots penetrating the bone, and in over-all penetration. Durability of the Tanto profile was of no surprise. In all prior testing no tip of Tanto profile had suffered damage. It is an interesting side-note that all three damaged heads having an arched profile suffered that damage on the angle-impact hits; where the combined skid-forces would have been at their greatest. They may have fared better on a more strongly built broadhead.

Clearly, the round and Tanto profile tips performed the best when it came to penetrating this fairly heavy bone; with the Tanto tip showing 25% more overall-penetration than the round tip. All shots were at equal impact-force; and on arrows identical in all aspects except broadhead tip-profile. This implies the Tanto profile required less force to penetrate the bone; retaining more force for penetration after the bone had been breeched. On the young buffalo, with perpendicular impact, all three shots with the Tanto tip penetrated not only the scapular flat, but the underlying rib as well.

What is a Tanto tip, and what does it look like? When I first encountered this tip-profile thirty years ago I had no term to identify it in Study records. The term “Tanto tip” I coined merely because the profile reminded me of two Tanto knives placed back to back. Accompanying photos should clarify what a ‘Tanto-tip’ looks like. “Tanto-tip” is a profile, and can be applied in any width; ergo, one can have a “narrow Tanto tip” or “wide Tanto tip”; a “COI Tanto tip”; or a non-COI Tanto tip.

After conducting these tip design test, a number of test-broadheads previously demonstrating a tendency to break or bend tips were modified to a COI Tanto profile. In tests subsequent to this modification no tip damage was encountered; on any hit from any angle. It may be recalled that one Tanto-tipped broadhead was damaged during ‘tip-testing’. The ‘test broadhead’ is one fairly ‘soft’, and which had shown a high tendency of blade-bends in prior test. Broadheads selected for subsequent tip-modification were ones with good blade strength, edge retention, and steel quality, but which had shown a *frequent tendency* to bend/break at the tip. This encompassed the Abowyer Custom; Eclipse; STOS; Wolverine; Magnus; Zwickey and BlackStump.

Tip designs tested included, from left: original needle-tip; COI arch-tip; COI round-tip; COI Tanto-tip; flat-tip; COI chisel-tip (flat); and COI concave-tip.

Tanto tip added to an Eclipse Broadhead

Tanto tip on a STOS Broadhead

ABowyer Custom with original tip (Lower) and Tanto tip (top).
Single-blade or multiblade: Probably the most often stated advantage of a multiblade broadhead is its larger cut area; the presumption being that they: (1) open a larger wound on the skin surface, reducing drag on the arrow shaft; (2) leave a better blood trail because of this larger skin opening; (3) are more lethal because the larger diameter of the wound channel is more likely sever more vessels and arteries.

Edge Bevels

Now that we have looked at the various options for the broadhead's tip, let's take a look at the different edge profiles that broadheads present. The most common edge bevel will be a double-bevel, with each bevel having an angle of 20 or 25 degrees. This results in a total angle bevel of 40 to

50 degrees. This is fairly close to the bevel-angle on most knives. This common bevel angle is most useful on knives, as it provides a good compromise between sharpness and how long the knife will hold its edge before needing to be re-sharpened.

Many outdoorsmen apply angles differing from this ‘all purpose’ sharpening angle, and I am among them. The Swiss Army knife I commonly carry, mostly for its many other useful blades, had two knife blades. One I sharpen at a 16 degree bevel (32^0 total) and the other at 20 degrees. The 20^0 beveled blade is use for general cutting chores. The much sharper; thinner-edged 16^0 bevel; is used for task where maximum sharpness is desired, or required. Much the same philosophy is applied to the many other knives and cutting tools commonly used on the hunt, or in and around camp. General-purpose camp knives are sharpened at 25 degree bevels; kitchen knives at 20 degrees; capeing knives at 16 degrees; gutting and skinning knives at 20 degrees; meat cleavers, hatchets and axes at 35 degrees.

Why these differing sharpen angles? Different task ask different things of the blade. Assuming blade-steel of equal quality, the thinner the edge, the sharper it is; but the thinner it is the more easily it can be damaged, and quicker it will become dulled during use. A skinning or gutting knife, with its 20 degree bevel, will stay sharp enough to do its chores for a considerable length of time before requiring it be re-sharpened. The thin, very sharp edge of a small capeing knife will need a touch-up every few minutes to maintain the high level of sharpness need to perform its take with utmost efficiency. An axe or meat-cleaver with a thin 160 bevel would rapidly become dull and/or damaged doing the chores to which they are commonly applied. By the same token, I don’t wish to use a meet-clever edge to try and cape around an animal’s eye, or turn an ear! Different edge bevel perform differently.

With high quality steel, the thinner the edge the sharper it will be. If the steel is of insufficient quality, a very thin edge will easily ‘roll’, rendering it ineffective. If the steel is too hard, the thinner the edge the more likely it is to chip or break along the cutting edge.

The hunting broadhead should be viewed as a single-use edge; one that must remain sharp only long enough to penetrate through an animal one time without becoming dulled. After each use it will be re-sharpened; or new blades inserted, if of the replaceable-blade type. But the broadhead’s edge must also be strong enough that it will not become damaged on impact with any of the animal’s tissues; including heavy bone.

For the absolute maximum in cutting effect, the bowhunter wants the very thinnest edge he can get while still maintaining enough edge strength to resist damage during heavy-bone impact. A thin edge and a thin blade are not the same thing. Because a blade is thin it does not mean the cutting-edge is also thin (or sharp). Few items in a woodworkers shop will be sharper than the blades of his wood-plains or wood chisels; both of which have very thick blades.

In the above we have discussed only double-bevel edges. The carpenter's plane and wood chisels all have a single-bevel edge. Why? Because it is easier to get a thinner and sharper edge on them than if one were to use a double bevel. If a twenty-five degree bevel is applied to only one side of a blade, the other side will be flat; having a zero-degree bevel. The total edge-angle will be 25 degrees; half that of a knife sharpened with a double-beveled edge of 25 degrees.

To have a usable single-bevel edge on a broadhead requires that the quality of the broadhead's steel be very good. If not, the thin edge will not be strong enough to prevent the edge rolling when bone is impacted.

Single-bevel edges are not familiar to many bowhunters. It was, to the best of my knowledge, Harry Elburg who first 'twigged-on' to the potential advantages a single bevel offered the modern bowhunter, in terms of edge thinness and sharpness. That was some 40-odd years ago. There are, however, numerous examples of ancient stone points having a single bevel design. Whether this came about as an easier way to get a sharp edge, or through some discovered cutting advantage, no one knows.

Long before I realized the 'why' behind their effectiveness I had started using Harry's Grizzly broadhead for most of my own hunting. This came about simply because the Grizzly performed better than any other broadhead tested during the original Natal Study. Without doubt, I have taken more big game with single-bevel broadheads than any other bowhunter; at least a few hundred animals. Because of their performance in the Natal Study, the 190 grain Grizzly became the 'benchmark' broadhead for all subsequent Arrow Lethality Studies. During the last three decades of testing and recording results I have found many interesting fact about how and why the Grizzly performed as well as it did; and a lot of the credit for their performance rest with the single-bevel.

After examining hundreds of shots penetrating through bone, by a multitude of different broadheads, a distinct difference was noted between the bone-splitting ability of single-bevel broadheads; compared to the double-bevel variety.

In the accompanying photos note the long splits in buffalo rib-bones caused by the Grizzly's single bevel. This type of bone-split is a normal occurrence with single-bevel broadheads; though frequently are not easily visible until the bone is thoroughly cleaned and/or dried. Commonly these splits extend 4" to 6" from the point of blade entry into the bone. Clearly visible in the photos is the "S" shaped hole created as the single bevel broadhead rotates while passing through the bone, as opposed to a straight cut created by the double bevel broadhead. The double cut broadhead hole in the photo is from a Deadhead.

A single bevel causes the broadhead/arrow to rotate during penetration. The rate of rotation varies with the bevel-angle; broadhead length and broadhead blade length and profile. My favored Grizzly makes one complete 360^0 rotation in 15 5/8" of penetration; at least it does through a dense foam medium. This is roughly four times the rotational-rate even a very heavy degrees of helical fletching imparts to an arrow in flight. The torque force applied by the broadhead's rotation during penetration causes the bone to be 'popped apart'. This bone-splitting effect is greater, and more common, on ribs and long bones (humerus, femur) than on flat bones (scapula), but not uncommon in either. A single bevel broadhead may tap into the arrow's rotational energy during this penetration, achieving useful work from arrow-energy generally wasted during penetration.

Splitting bone, as opposed to cutting a blade-size hole through it, is a desirable feature in broadhead design. The penetration difference shown between like-broadheads having different types of edge bevels indicates that bones that have been 'split' permits easier arrow-passage through the bone; reducing arrow drag and increasing penetration.

To verify and quantify this effect when bone was encountered, a series of test were conducted. Thanks to Ben Pearson Jr., a number of Deadhead blanks; broadheads to which edge-bevels had never beed applied; were secured. These were beveled with a 25^0 right hand single bevel. They were then used as a comparison to Deadheads having a 25^0 double bevel edge finish. As an additional test of edge-type effects on bone penetration, Alan Woodward, maker of the Outback Broadheads supplied several samples of his broadheads; some with a right hand single bevel; some a left hand single bevel; and some with double bevel. Several samples of each were supplied in both a long-narrow and short-wide broadhead. These single bevels were also set at $25^{0;}$ with corresponding double bevels at 25^0.

The first Chart below shows the comparative results the testing of the Deadheads. The second Chart gives results with the experimental Outback broadheads tested. All the shots were broadside at 20 yards. Each shot series were fired in matched sets, so that equality between test subjects and edge types tested was maintained. The Deadheads were tested on tapered hickory shafts from the 70# longbow used during tip-testing. The Outback's tested were on 2219 aluminum shafts, and a 65# compound was used.

On rib-impact shots, single bevel Deadheads had 31% more average penetration than their double bevel companions. On scapula hits, single bevels showed a 40% advantage in penetration. The Outback broadheads were used only on rib-impact shots. The narrow single-bevels showed 58% greater penetration than those double-beveled; and the wide-cut Outback's showed a 49% increase when single-beveled.

Next, a few shots were taken to see how much effect the direction of arrow rotation would affect a single-beveled broadheads penetration. Two shots were taken with both a narrow and a wide-cut Outback having a left-hand single bevel, and mounted on a right-fletched shaft. This created a situation where the direction of broadhead-induced rotation was opposite the arrow-rotation caused by the fletching. These showed a marked penetration decrease from the corresponding right-hand beveled/fight-hand fletched narrow and wide-cut samples; 42% and 67%, respectively. With single bevel heads it is important that the direction of arrow-rotation in flight match the direction of bevel-induced rotation.

This limited sampling comprised only 45 shots, but the findings were consistent; and with three broadheads of vastly differing profiles. Both the average penetration and the median penetration, among all shots, showed a clear advantage for single bevel broadheads in penetrating through bone. Single bevel broadheads do offer a pronounced advantage in penetration when bone is encountered.

Deadhead Bevel Test

N_{Total} = 20

N=	**Deadheads**	**Avg. Mass**	**Average Impact Kinetic Energy**	**Average Impact Momentum**	**Average Penetration (Inches)**	**Penetration Range (Inches)**	**Median Penetration (Inches)**
5	Double-Bevel:	770	31.62	0.46	7.75	5.9 - 7.6	7.25

	Scapula Impact						
5	Single-Bevel: Scapula Impact	770	31.62	0.46	9.85	5.4 - 12.1	10.25
5	Double-Bevel: Rib Impact	770	31.62	0.46	12.03	2.8 - 20.0	13.875
5	Single-Bevel: Rib Impact	770	31.62	0.46	18.03	14.9 – 22.9	18.125

Experimental Outback Test

N_{Total} = 25

N=	**Exp. Outback (Rib Impact)**	**Avg. Mass**	**Average Impact Kinetic Energy**	**Average Impact Momentum**	**Average Penetration (Inches)**	**Penetration Range (Inches)**	**Median Penetration (Inches)**
8	***Narrow-Cut Double-Bevel	684	44.58	0.52	12.75	9.8 - 11.6	11.63
5	Narrow-Cut Single-Bevel	662	43.99	0.51	17.63	14.5 - 19.25	18.125
4	Wide-Cut Double-Bevel	660	43.85	0.51	10.59	7.0 - 15.3	10.06
4	Wide-Cut Single-Bevel	660	43.85	0.51	14.28	12.0 – 15.3	14.94
2	Left Narrow-Cut Single-Bevel Right-Fletch	662	43.99	0.51	10.75	8.0 - 13.5	10.5
2	Left Wide-Cut Single-Bevel Right-Fletch	660	43.85	0.51	4.94	4.9 – 5	4.96

* Includes 3 shots with prototype: thicker, heavier, having same profile.

This photo shows the exit side for side of the buffalo ribs. Single-bevel exits are on the left-hand side; and single-bevel on the right. These bones have been thoroughly cleaned and bleached to more clearly show the splits; but were fresh-bone when the shots were taken.

This photo shows the entrance side for single and double-bevel broadhead. The double-bevel entrance shown here (left) was made by a Deadhead. The five-inch long bone-split shown on the left was made by a single-bevel Grizzly Extreme; only 11/16: wide. As before, these bones have been cleaned, bleached and dried for the photo; but were shot when fresh.

Close-up photo clearly showing the rotation a single-bevel induces when penetrating bone. This is particular split is from a 1” wide Modified Grizzly.

A Deadhead, edged with a right-hand single bevel of 25 degrees.

Narrow and wide-cut Outback broadheads tested. Left to right: narrow-cut double bevel (left); wide-cut double-bevel; wide-cut right-hand single-bevel; narrow-cut right-hand single-bevel. Not show are the left-hand single-bevel heads tested. They would be the same as two single-bevel heads shown; merely with the bevel on the opposite edge of the broadhead.

There are some other broadhead features, other than those discussed above, which enter into the arrow performance equation. These we will cover as they arise in discussion of other arrow characteristics relative to potential lethality.

The ‘golden rule’ which one should always follow when building hunting arrows: start with a really good broadhead and then setup your hunting arrow, and your bow, around the broadhead.