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TABLE OF CONTENTS

INTRODUCTION TO THE INNAGURAL VOLUME

It is with great pleasure that I unleash this journal on the world, and I anxiously await the exciting submissions that have already begun to fill it and will no doubt continue to do so for many years to come. My excitement stems from the boundless enthusiasm of young people for learning new things. As a high school science teacher, I am in the unique position of watching my students shove off into the big and ever-changing world around them, and it's invigorating to imagine what amazing things they might accomplish in their lives.

I often pause to think about the fact that Newton had a science teacher at some point; so too did Einstein, Darwin and Franklin. I wonder if their teachers had any idea about what they would go on to accomplish. I certainly have no conception of which of my students will go on to make a fantastic scientific discovery, but I am positive that some of them will. And I wonder if the opportunities that are provided to them can make a difference. In this case, as compared to the former, I can be a bit surer of my answer. I know that providing students an outlet for their work can make them more ambitious and more likely to succeed. Science teachers around the world know that we are teaching valuable life skills, but it's not within the developmental abilities of the average teenager to think such long-term thoughts.

To put the idea another way, school can sometimes seem like a whole year full of basketball practices with no basketball game. What motivation is there to succeed if there is no game to put one's skills to good use? By the same token, can we blame students for becoming disenchanted with a science class that doesn't give them a chance to show off what they've learned?

It is my sincere desire for this journal to become an outlet and a goal for science students. I hope that they will see the beauty and the sheer utility that science offers in solving the increasing number of problems that humans encounter. I hope that you enjoy reading about the discoveries that our authors have made, and that they will inspire you to go out and make a discovery, however small, yourself.

D.M.S
2014
Ithaca, NY

THE EFFECTS OF THE COEFFICIENT OF FRICTION ON THE ABILITY OF A LADDER LEANING AGINAST A WALL TO STAND

Tongtian Liu, Brighton high School, Rochester, NY

ABSTRACT:

This article investigates how the coefficient of friction relates to a ladder's ability to lean against a wall. The paper does this through examining the forces acting on the ladder while it is leaning. With physical equations involving the sum of torques and forces, an equation relating the angle of the ladder with the ground and the necessary coefficient of friction for the ladder to stand is derived. It found that $\tan(\theta) = \frac{1}{2\mu_f} - \frac{\mu_w}{2}$. For example, a wooden ladder on a concrete floor (μ_f =0.6) leaning against a sheet of ice (μ_w =0) would need to have a minimum angle of 0.695 (39.8°). The symbols are explained in table 1.

INTRODUCTION:

The purpose of the work is to investigate the necessary coefficient of friction for a leaning ladder to stay standing. It will discuss what happens when there is no friction between the ladder and the wall, no friction between the ladder and the floor, and the case in which there is friction between the ladder and both the wall and the floor.

The effects of friction on a ladder can have practical applications, such as when a ladder is on ice, a puddle of oil, or other slippery surfaces. It is important to know whether the ladder can stand in these cases.

THEORY:

Here are some symbols this report uses to represent various values.

Symbol	Name	Explanation
F_g	Force due to gravity	This is gravity pulling down on the ladder. Although the force is actually acting on every point of mass on the ladder, we can treat it as if all of the mass were concentrated at the appropriately named center of mass. Measured in newtons.
F_n	Normal force from the ground	This is the force that the floor exerts on the ladder to prevent the ladder from falling through the floor. Measured in newtons.

F_w	Normal force from the wall	This is the force that the wall exerts on the ladder to prevent the ladder from falling through the wall. Measured in newtons.
μ_f	Coefficient of friction between the ladder and the floor	This is the coefficient that contributes to the frictional force. It indicates how "rough" the surface between the ladder and the floor is. The lower the coefficient, the more "slippery" is the ladder and the ground.
μ_w	Coefficient of friction between the ladder and the wall	This is the coefficient that contributes to the frictional force. It indicates how "rough" the surface between the ladder and the wall is. The lower the coefficient, the more "slippery" is the ladder and the wall.
F_f	Frictional force from the ground	This is the force that prevents the ladder from sliding on the ground. The equation is $F_f = F_n\mu_f$. Measured in newtons.
F_{fw}	Frictional force from the wall	This is the force that prevents the ladder from sliding against the wall. The equation is $F_{fw} = F_w\mu_w$. Measured in newtons.
θ	The angle between the ladder and the ground	The angle, measured in radians.
L	The length of the ladder	This is how long the ladder is. Measured in meters.

Table1. Variables and their definitions relative to this paper.

Some equations:

Force:

F = ma. If an object is at constant velocity or not moving (like the case of the standing ladder), the net force is equal to zero (i.e. $\Sigma F_{net} = 0$). That means that the forces acting up cancel the forces acting down, and the forces acting left cancel the forces acting right, etc. We can simplify force problems by breaking up the vectors in to horizontal and vertical components.

The types of forces we have are the gravitational force, normal force, and the frictional force.

Normal Force:

The normal force is always perpendicular to the surface from which it originates, and it is the amount of force necessary to prevent the object from falling through the surface (e.g. the normal force acting on a 10kg box that lies on a flat surface is 980N on Earth, and it points directly away from the center of the Earth).

Friction:

$F_f \leq \mu N$ (friction is FμN); μ is the coefficient of friction, and N is the normal force. By letting friction equal to the normal force times the coefficient, we indicate that two surfaces are on the verge of slipping, which we will do to simplfy calculations.

Torque:

$\tau = r \times F$, or $\tau = r F \sin\theta$ where F is the applied force, r is the distance between the force and the pivot point, and θ is the angle between the force and the object that the force is being applied to. Torque can be thought of as the "angular force."

Each torque has a vector; to keep this lab simple, we will say that any torque that "pushes" counterclockwise is positive, and any torque that "pushes" clockwise is negative. The angular acceleration of a still ladder is zero; so when we add up all the torques that are acting against the ladder, we can set the sum equal to zero (i.e. $\Sigma \tau = 0$).

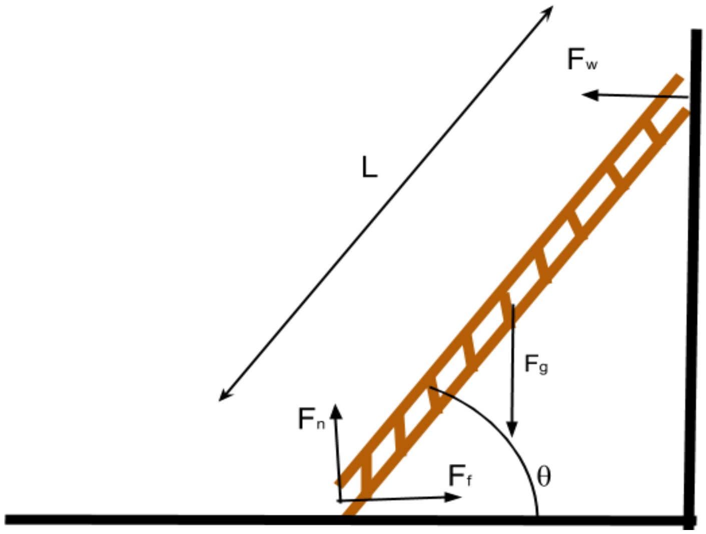
Angles:

This paper will measure everything in radians because radians are derived from the definition of the angle. To relate this with degrees: $90° = \pi/2$, $180° = \pi$, $270° = 3\pi/2$, etc.

Note: pay attention to any numbered equation because those will be later used in substitutions.

PROCEDURE:

To achieve our goal, we will investigate three cases: friction on the floor but not the wall, friction on the wall but not the floor, and friction on both the wall and the floor. We will start with the case in which there is no friction between the wall and the ladder. If there were no friction on the wall, one would expect that the ladder would stay standing if the friction from the floor is enough to keep the ladder from slipping. We can illustrate this with a diagram (all symbols are explained in the theory section):



F_g	Force due to gravity
F_n	Normal force from the ground
F_w	Normal force from the wall
F_f	Frictional force from the ground
θ	The angle between the ladder and the ground
L	The length of the ladder

In this paper, we will set counter clockwise as the positive torque direction, up as the positive vertical direction, and right as the positive horizontal direction. To solve the relationship between the friction and angle, we will use some of the equations we described in the theory section to indicate the necessary coefficient of friction for the ladder to stand. First, we will start with a torque equation and set the pivot point to be at the bottom of the ladder. The normal force and frictional force are at the pivot, so their distances are zero, so they do not contribute to the torque when the pivot is set to the bottom.

The gravitational force is at L/2 away from the bottom, and the angle between it and the ladder is $\pi/2-\theta$; the force pushes the ladder clockwise, so the torque is negative. The normal force from the wall is L away from the pivot, and the angle is θ; the force pushes the ladder counterclockwise, so the torque is positive.

Adding together all the torques, we have:

$$\Sigma\tau_{bottom} = -F_g \frac{L}{2}\sin(\pi/2-\theta) + F_w L\sin(\theta)$$

Because the ladder is not moving, the net torque is equal to zero. $\sin(\pi/2-\theta)$ is also equal to $\cos(\theta)$ by the trigonometric identity. Thus:

$$0 = -F_g \frac{L}{2}\cos(\theta) + F_w L\sin(\theta)$$

Now, we simplify the equation:

$$F_g \frac{L}{2}\cos(\theta) = F_w L\sin(\theta)$$

(1) $$\frac{F_g}{2} = F_w \tan(\theta)$$

We want to relate the angle with the coefficient of friction, so we need to find F_w and F_g to put the equation in terms of these values. We can find the sum of the forces in the horizontal and vertical components. There is a frictional force acting right and a normal force acting left, so:

$$\Sigma F_x = F_f - F_w$$

The ladder is not moving, which means that the net force is 0, so:

$$0 = F_f - F_w$$

(2) $$F_f = F_w$$

There is a gravitational force acting down and a normal force acting up, so:

$$\Sigma F_y = F_n - F_g$$

The ladder is not moving, which means that the net force is 0, so:

$$0 = F_n - F_g$$

(3) $$F_n = F_g$$

By substituting equation (2) and (3) into equation (1), we have:

(4) $$\frac{F_g}{2} = F_w \tan(\theta) \rightarrow\rightarrow \frac{F_n}{2} = F_f \tan(\theta)$$

As mentioned in the theory section, $F_f = F_n u_f$. We can substitute F_f into equation (4).

$$\frac{F_n}{2} = F_f \tan(\theta) \rightarrow\rightarrow \frac{F_n}{2} = F_n \mu_f \tan(\theta)$$

By simplifying, we have:

$$\frac{1}{2} = \mu_f \tan(\theta)$$

(5) $$\frac{1}{2}\cot(\theta) = \mu_f$$

This means that **as long as the coefficient of friction between the floor and the ground is greater than $\frac{1}{2}\cot(\theta)$, then the ladder will stand**. Equation (5) also indicates that as the angle increases, the necessary coefficient of friction decreases (since cot (θ) decreases as θ increases), and vice versa. This makes sense, because if the angle between the ladder and the ground is small, the frictional force needs to be much greater to push on the ladder, while if the angle between the ladder and the ground is large, the frictional force can be smaller.

As a practical example, imagine a wooden ladder leaning against a sheet of ice on a concrete floor. The coefficient of friction between wood and concrete is about 0.6, and we will assume that the friction between the ice and the ladder is negligible. So with our equation (5), we can find the range of angles at which the ladder can stand.

$$\frac{1}{2}\cot(\theta) \leq \mu_f$$

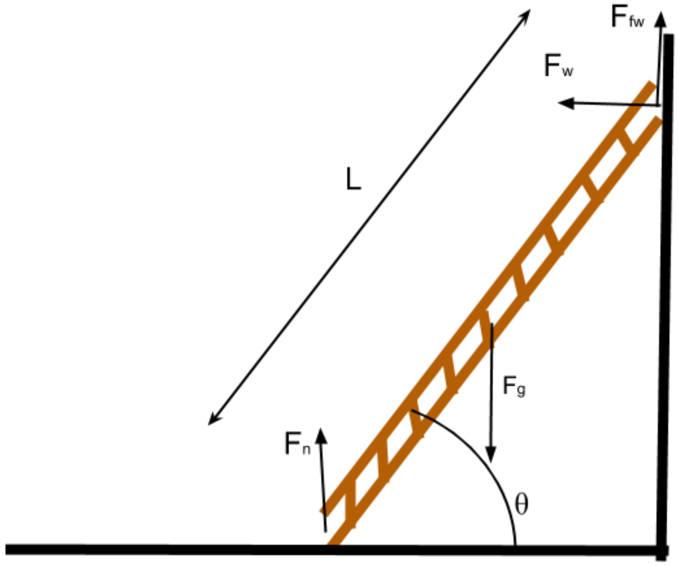
$$\frac{1}{2}\cot(\theta) \leq 0.6$$

$$\cot(\theta) \leq 1.2$$

$$0.695 \geq \theta \geq \pi/2 \text{ or } 39.8° \geq \theta \geq 90°$$

Thus, if a ladder on a floor of concrete is leaning against a sheet of ice (or other surface with low friction), the ladder can only stand under at angles above 0.695. That's something to keep in mind when one wishes to lean a wooden ladder against a sheet of ice.

Now, we will examine the case in which there is friction between the wall and the ladder, but no friction between the floor and the ladder. This situation can again be modeled with a diagram:



F_g	Force due to gravity
F_n	Normal force from the ground
F_w	Normal force from the wall
F_{fw}	Frictional force from the wall
θ	The angle between the ladder and the ground
L	The length of the ladder

The forces are the same. But this time, instead of friction on the ground, there is friction on the wall. Also, like in the previous case, we can set up some sum of the forces and sum of the torques equations.

Again, we start by setting the pivot point to be at the bottom. There is a gravitational force acting L/2 away from the pivot with angle $\pi/2-\theta$, causing a “clockwise” torque. There is a normal force acting L away from the pivot with angle θ, causing a “counterclockwise” torque. There is a frictional force acting L away from the pivot with angle $\pi/2+\theta$, causing a “counterclockwise” torque. By adding these up, we have:

$$\Sigma\tau_{bottom} = -F_g\frac{L}{2}\sin(\pi/2-\theta) + F_w L\sin(\theta) + F_{fw}L\sin(\pi/2+\theta)$$

And, because we are assuming that the ladder is not moving, the net torque is still zero. We also apply some trigonometric identities:

$$0 = -F_g\frac{L}{2}\cos(\theta) + F_w L\sin(\theta) + F_f L\cos(\theta)$$

Simplifying:

$$F_g\frac{L}{2}\cos(\theta) = F_w L\sin(\theta) + F_{fw}L\cos(\theta)$$
$$\frac{F_g}{2}\cos(\theta) = F_w\sin(\theta) + F_{fw}\cos(\theta)$$

As we mentioned in the theory section, $F_{fw}= F_w u_w$, so by substitution:

$$\frac{F_g}{2}\cos(\theta) = F_w\sin(\theta) + F_{fw}\cos(\theta) \rightarrow\rightarrow \frac{F_g}{2}\cos(\theta) = F_w\sin(\theta) + \mu F_w\cos(\theta)$$

Now, we simplify the equation and solve for F_w:

$$\frac{F_g}{2}\cos(\theta) = F_w \sin(\theta) + \mu F_w \cos(\theta)$$
$$\frac{F_g}{2}\cos(\theta) = F_w\,(\sin(\theta) + \mu\cos(\theta))$$

(6)
$$F_w = \frac{F_g \cos(\theta)}{2(\sin(\theta)+\mu\cos(\theta))}$$

Again, we want the equation in terms of angle and coefficient of frictions, so now we set up another sum of the torques equation with the pivot point at the top of the ladder to find these values. Gravitational force: distance L/2 angle π/2-θ, counterclockwise. This time, the gravitational force is counterclockwise because we are now looking from the perspective of the pivot point at the top of the ladder. Normal force: distance L, angle π/2-θ, clockwise. After adding these up, we get:

$$\Sigma\tau_{top} = F_g \frac{L}{2}\sin(\pi/2 - \theta) - F_n L \sin(\pi/2 - \theta)$$

Again, the net torque is zero because we assume the ladder is not moving. We also use more trig identities:

$$0 = F_g \frac{L}{2}\cos(\theta) - F_n L\cos(\theta)$$

Simplifying:

$$F_g \frac{L}{2}\cos(\theta) = F_n L\cos(\theta)$$

(7)
$$\frac{F_g}{2} = F_n$$

To get further, we must set up sum of the forces equations. In the vertical direction, there is a normal force up, frictional force up, and a gravitational force down. Their sum:

$$\Sigma F_y = F_n + F_{fw} - F_g$$

Since we are assuming the ladder is not moving, the net force is zero. Also, we substitute $F_w\mu_w$ for F_{fw} as we noted for the theory section:

$$0 = F_n + \mu F_w - F_g$$

Simplifying:

(8) $$F_n + \mu F_w = F_g$$

Now, we will do some massive substitutions. Equation (8) has terms of F_n and F_w, and we have previously solved for these in terms of F_g, so we will substitute F_w from equation (6) and F_n from equation (7) into equation (8).

$$F_n + \mu F_w = F_g \rightarrow\rightarrow \frac{F_g}{2} + \mu F_w = F_g$$
$$\frac{F_g}{2} + \mu F_w = F_g \rightarrow\rightarrow \frac{F_g}{2} + \mu(\frac{F_g \cos(\theta)}{2(\sin(\theta) + \mu\cos(\theta))}) = F_g$$

Now, we simplify the equation:

$$\frac{F_g}{2} + \frac{\mu F_g \cos(\theta)}{2(\sin(\theta)+\mu\cos(\theta))} = F_g$$
$$\frac{1}{2} + \frac{\mu\cos(\theta)}{2(\sin(\theta)+\mu\cos(\theta))} = 1$$
$$\frac{\mu\cos(\theta)}{(\sin(\theta)+\mu\cos(\theta))} = 1$$
$$\mu\cos(\theta) = \sin(\theta) + \mu\cos(\theta)$$
$$\sin(\theta) = 0$$

But that gives us θ=0, which means the ladder is lying flat on the ground. That's not what we want, and it also does not give us a value for the coefficient of friction. Let's try again, this time with a sum of the forces horizontally. There is only one force in the horizontal direction.

$$\Sigma F_x = F_w$$

But we are assuming the ladder is not moving because it is leaning against the wall.

(9) $$F_w = 0$$

Then, we substitute F_w from equation (6) into equation (9) :

$$F_w = 0 \rightarrow\rightarrow \frac{F_g \cos(\theta)}{2(\sin(\theta) + \mu\cos(\theta))} = 0$$

(10) $$\frac{F_g \cos(\theta)}{2(\sin(\theta)+\mu\cos(\theta))} = 0$$

That means the numerator is equal to zero, so:

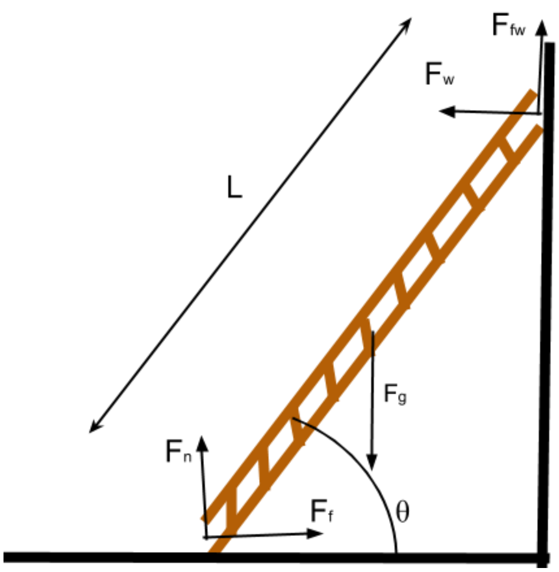
$$0 = F_g \cos(\theta)$$
$$0 = mg\cos(\theta)$$

But that means the ladder can only stand if there is no mass, no gravity, or cos θ is equal to zero, which gives us θ=π/2. That means the ladder is standing straight up, not leaning against the wall. Furthermore, we still do not have a value for μ.

We are desperate. With equation (10), we will venture into the forbidden zone of mathematics: division by zero.

$$\frac{F_g \cos(\theta)}{2(\sin(\theta) + \mu\cos(\theta))} = 0$$
$$2(\sin(\theta) + \mu\cos(\theta)) = \frac{F_g \cos(\theta)}{0}$$
$$2\mu\cos(\theta) = \frac{F_g \cos(\theta)}{0} - 2\sin(\theta)$$
$$2\mu = \frac{F_g}{0} - 2\tan(\theta)$$
$$\mu = \frac{F_g}{0} - \tan(\theta)$$

There we go. The coefficient of friction between the ladder and the wall must be at least $\frac{F_g}{0} - \tan(\theta)$, which gives us an undefined μ. To make more sense of this, we will solve for the case when there is friction both on the wall and the floor. This is the most realistic case; there is friction with both the wall and the floor.



F_g	Force due to gravity
F_n	Normal force from the ground
F_w	Normal force from the wall
μ_f	Coefficient of friction between the ladder and the floor
μ_w	Coefficient of friction between the ladder and the wall
F_f	Frictional force from the ground
F_{fw}	Frictional force from the wall
θ	The angle between the ladder and the ground
L	The length of the ladder

This time, I will not lay out every step because it would be too chaotic.

Sum of the torques with pivot at bottom:

$$\Sigma\tau_{bottom} = -F_g\frac{L}{2}\sin(90° - \theta) + F_w L\sin(\theta) + F_{fw} L\sin(90° + \theta)$$
$$0 = -F_g\frac{L}{2}\cos(\theta) + F_w L\sin(\theta) + \ \mu_w F_{fw} L\cos(\theta)$$
$$\frac{F_g}{2}\cos(\theta) = F_w\sin(\theta) + \mu_w F_{fw}\cos(\theta)$$
$$\frac{F_g}{2}\cos(\theta) = F_w(\sin(\theta) + \mu_w\cos(\theta))$$

(11) $$\frac{F_g\cos(\theta)}{2(\sin(\theta)+\mu_w\cos(\theta))} = F_w$$

Sum of the torques with pivot at the top:

$$\Sigma\tau_{top} = F_g\frac{L}{2}\sin(90° - \theta) - F_n L\sin(90° - \theta) + F_f L\sin(\theta)$$
$$0 = \frac{F_g}{2}\cos(\theta) - F_n\cos(\theta) + F_f\sin(\theta)$$
$$\frac{F_g}{2}\cos(\theta) = F_n\cos(\theta) - \mu_f F_n\sin(\theta)$$
$$\frac{F_g}{2}\cos(\theta) = F_n(\cos(\theta) - \mu_f\sin(\theta))$$

(12) $$\frac{F_g\cos(\theta)}{2(\cos(\theta)-\mu_f\sin(\theta))} = F_n$$

Sum of the forces horizontally:

$$\Sigma F_x = F_f - F_w = 0$$

(13) $$\mu_f F_n = F_w$$

$$\Sigma F_y = F_n - F_g + F_{fw} = 0$$

Now, we substitute F_w from equation (11) into equation (13):

$$F_w = \mu_f F_n \to\to \frac{F_g\cos(\theta)}{2(\sin(\theta) + \mu_w\cos(\theta))} = \mu_f F_n$$

(14) $$\frac{F_g\cos(\theta)}{2\mu_f(\sin(\theta)+\mu_w\cos(\theta))} = F_n$$

Now, we substitute F_n from equation (12) into equation (14).

$$F_n = \frac{F_g\cos(\theta)}{2\mu_f(\sin(\theta)+\mu_w\cos(\theta))} \to\to \frac{F_g\cos(\theta)}{2(\cos(\theta)-\mu_f\sin(\theta))} = \frac{F_g\cos(\theta)}{2\mu_f(\sin(\theta)+\mu_w\cos(\theta))}$$

Simplifying:

$$2(\cos(\theta)-\mu_f\sin(\theta)) = 2\mu_f(\sin(\theta)+\mu_w\cos(\theta))$$
$$\cos(\theta)-\mu_f\sin(\theta)) = \mu_f\sin(\theta)+\mu_w\mu_f\cos(\theta)$$
$$\cos(\theta)-\mu_f\mu_{fw}\cos(\theta) = 2\mu_f\sin(\theta)$$
$$1-\mu_f\mu_{fw} = 2\mu_f\tan(\theta)$$
$$\frac{1}{2\mu_f}-\frac{\mu_w}{2} = \tan(\theta)$$
$$\mu_f = \frac{1}{2\tan(\theta)+\mu_w} \quad \text{or} \quad \mu_w = \frac{1}{\mu_f}-2\tan(\theta)$$

The equation becomes $\frac{1}{2\mu_f}-\frac{\mu_w}{2} \leq \tan(\theta)$ because the angle can be greater than the situation in which the ladder is on the verge of slipping (see theory section). Thus, **the ladder would be able to stand as long as $\tan(\boldsymbol{\theta})$ is greater than $\frac{1}{2\mu_f}-\frac{\mu_w}{2}$.** These equations indicate that as the angle increases, the ladder will still stand even with a smaller coefficient of friction between the ladder and the wall or floor: i.e. as θ increases, $\frac{1}{2\mu_f}-\frac{\mu_w}{2}$ can be larger and the ladder will still stand. That expression increases when μ_f decreases (μ_f is inversely proportional) and when μ_w decreases ($-\mu_w$ is directly proportional). This means that as the angle increases, the frictional force can be smaller.

For example, going back to the previous situation with the concrete and ice, if we wanted to lean the ladder at π/6 (30°), the coefficient of friction between the ladder and the sheet of ice would need to be:

$$\mu_w = \frac{1}{\mu_f}-2\tan(\theta)$$
$$\mu_w = \frac{1}{0.6}-2\tan\left(\frac{\pi}{6}\right)$$
$$\mu_w = 0.512$$

Ice would not have such a high coefficient of friction, so it would be difficult to lean a wooden ladder against a sheet of ice at π/6 (30°). But if we set lean the ladder at a somewhat larger angle, such as 3π/14 (38.6°, only 8.6° more), the coefficient of friction between the ice and the ladder would only need to be:

$$\mu_w = \frac{1}{\mu_f}-2\tan(\theta)$$
$$\mu_w = \frac{1}{0.6}-2\tan\left(\frac{3\pi}{14}\right)$$
$$\mu_w = 0.072$$

This coefficient is very realistic.

CONCLUSIONS:

The equations indicate that the mass of the ladder and its length do not affect its ability to stand. It is possible to think about this intuitively: if the mass increased, then its force downward would increases, but the normal force increase too, providing a larger frictional force; it turns out that a changing mass's effects on the frictional force and gravitational force would cancel out. The length does not matter either. Think about it this way: if the ladder was longer, it is as if we "zoomed out"; if the ladder was shorter, it is as if we "zoomed in."

The equations also indicate that **if the coefficient of friction between the floor and the ladder is zero, the ladder can't stand** since the fraction becomes undefined. This could be the case when the floor is ice instead of concrete. This confirms what we found in the case that the floor was frictionless: if the floor was frictionless, the ladder could only stand if the mass of the ladder was zero, if the gravitational field was zero, if the ladder was completely upright, or if the ladder was lying on the ground. Any attempt to find a coefficient of friction of the wall with a frictionless floor only returns an undefined value.

This result may be counterintuitive. Surely, friction on the wall can keep a ladder standing, even if the floor were frictionless, right? It is key to remember that friction is the product of the normal force and its coefficient. If there is no normal force, then there cannot be friction. The normal force provided by the wall pushes the ladder away from the wall, but there is no force to oppose the ladder. So the ladder is pushed away from the wall, and the normal force becomes zero. Since the normal force is zero, there is no frictional force to hold up the ladder.

Like a house divided against itself, a ladder on a surface without friction cannot stand.

Assessing the Variation in Biodiversity Between Two Locations on the Olentangy River in Worthington, Ohio

Ashish Vankara and Christina Yun Liu, Thomas Worthington High School, Colombus, OH

ABSTRACT:

The purpose of the experiment was to examine the correlation between habitat characteristics and biodiversities of two locations along the Olentangy River in Worthington, Ohio, and to compare and contrast the biodiversities of the locations. The completed research demonstrated that certain characteristics of habitats affect the biodiversity of a freshwater ecosystem, sometimes adversely. In each location, the physical characteristics of the corresponding habitats were quantified through the completion of Qualitative Habitat Evaluation Index (QHEI) reports following systematic procedures. The QHEI scores were 73 and 61 for the Highbanks site and the school site respectively. At the Highbanks site, a grid made of stakes of the dimensions six meters by six meters was set up. A sample was collected at each stake and the organisms were collected and recorded. The same was done at the school site except the samples were taken along a thirty meter long transect line in five meter intervals. To calculate the biodiversity of the two habitats, the Shannon-Weiner Index was computed for each site. The Shannon-Weiner Indexes were 1.61 and 1.52 for the Highbanks site and the school site respectively, thereby showing that the Highbanks site has a higher level of biodiversity than that of the school site. The QHEI scores and biodiversity (calculated with the Shannon-Weiner Index) are positively correlated. In the future, researchers could analyze the extent to which a certain physical feature of a habitat affects its biodiversity. This data could be used as justification to prevent ecologically damaging development of land.

INTRODUCTION:

The purpose of this investigation was to distinguish certain similarities and differences in biodiversity in different locations on the Olentangy River. The first location on the Olentangy River (Highbanks Park) was located at 40.3555°N and 83.0672°W. The second location on the Olentangy River (school site) was located at 40.110 °N and 83.032 °W (See Appendix). It was hypothesized that the site near the school would have a lower biodiversity because of the low flow rate and the presence of adverse human interaction.

Biodiversity is the population heterogeneity of a community, i.e. the number of species in a given area. One common method of determining biodiversity is the Shannon-Wiener Index (represented by the value H). H ranges from 0 (a community without any diversity or a single species) to 7 (a community with an infinite amount of diversity) (Shannon, 2013). Pollution and human presence have been known to affect biodiversity in ecosystems, usually adversely. This study showed the correlation between human presence and lack of biodiversity.

The substrate types, in-stream cover, channel morphology, bank erosion/ riparian zone, pool/glide depth, riffle/run quality, and gradient affect the biodiversities of rivers. QHEI reports or Qualitative Habitat Evaluation Index and Use Assessment Field Shield reports incorporate all of these natural qualities and compile the data into a score that can be directly related to diversity (See Appendix for more information about QHEI reports). A lower score correlates to lower biodiversity and a higher score correlates to a higher biodiversity. The maximum possible score for QHEI is 100 (Taft, 2006).

MATERIALS:

- 6 wooden stakes to create grid and transect lines
- 2 shower curtains to sort and count arthropods
- Hammer to set up stakes
- Net to catch arthropods
- Tweezers to examine organisms closely
- Aquatic Macro-invertebrate Identification sheet
- Tape measure to create grid and transect lines
- Transect line wire/rope

PROCEDURE (See appendix)

Highbanks Site:

The QHEI report was completed according to the OHIO EPA Technical Bulletin EAS/2006-06-1. A location along the river away from disturbance was selected for the sampling. A 6m by 6m square grid was constructed. This was done by an experimenter inserting a stake into the substrate and two other experimenters measuring a 6m square with the first stake being one vertex using the tape measure. A stake was placed at each vertex yielding a 6m by 6m square. A showering curtain was laid out on the ground as a place to count and characterize organisms. A sample was taken by two experimenters holding the net downstream at one of the stakes and another experimenter disrupting the substrate (less than a meter away from the net) to cause the organisms to come out. After approximately one minute, the net was taken out of the water and laid out on the shower curtain. The experimenters counted and distinguished the species of arthropods.

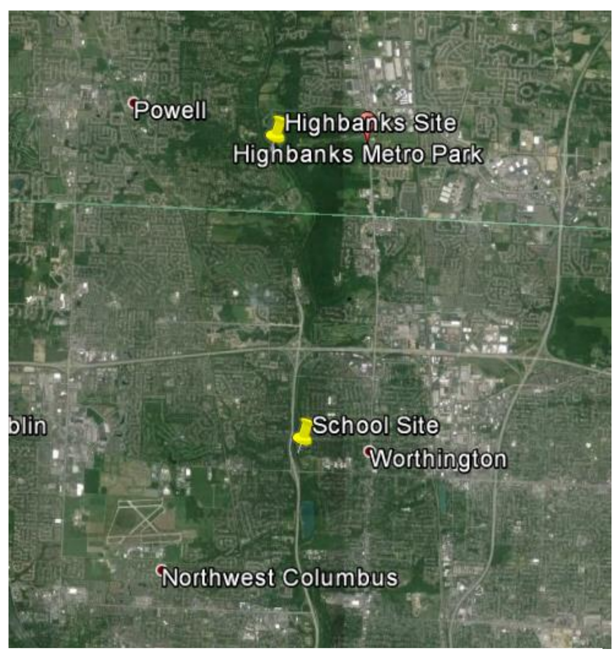


Figure 1. Satellite image of collection sites.

Both the shower curtain and the net were taken into the water and rinsed. The shower curtain was laid down again and the same process was repeated for the three other stakes. After all four samples of the grid were collected, the stakes were taken out and rinsed. Also, the shower curtain and net were rinsed and folded up for transportation. All the materials were removed from the sampling site.

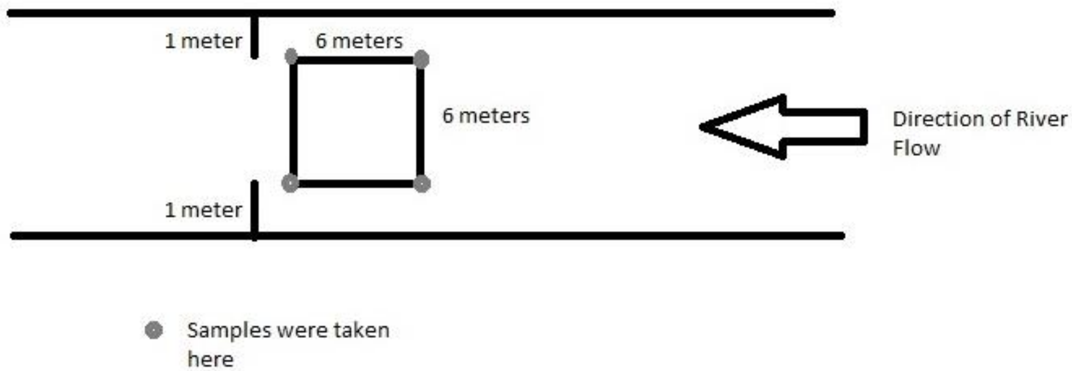


Figure 2. Highbanks collection site.

School Site:

The QHEI report was completed according to the OHIO EPA Technical Bulletin EAS/2006-06-1. A location along the river away from disturbance was selected for the sampling. A transect line was constructed using a two stakes, a rope, a tape measure, and a hammer. The two stakes were hammered in approximately 5m from the shore. A shower curtain was laid out on the ground to provide a place to count organisms. A sample was taken by two experimenters holding the net downstream with 5m separating each sample location (and stake for the samples close to shore). Another experimenter disrupted the substrate (less than a meter away from the net) to cause the organisms to come out. After approximately one minute, the net was taken out of the water and laid out on the shower curtain. The experimenters counted and distinguished the species of arthropods. Both the shower curtain and the net were taken into the water and rinsed. The shower curtain was laid down again and the same process was repeated for the three other sampling locations (5m apart from each other) along the transect line. After all four samples were taken, all of the materials were removed from the area.

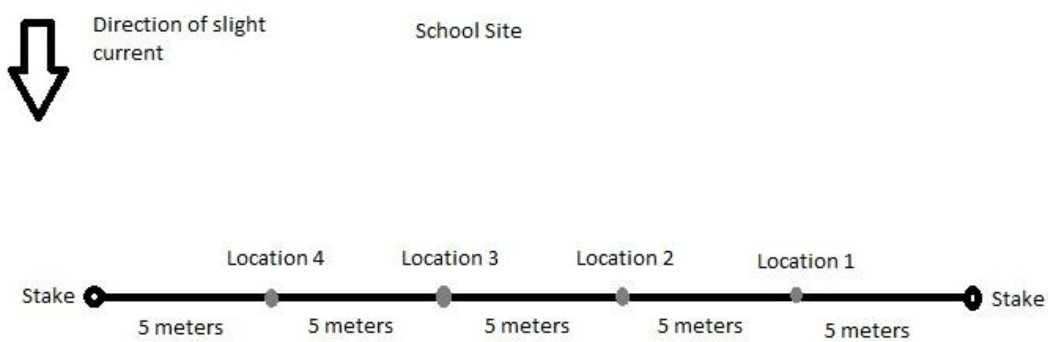


Figure 3. School collection site.

RESULTS:

The QHEI score for the Highbanks site was 73. (See Appendix for QHEI Forms)
The QHEI score for the schools site was 61. (See Appendix for QHEI Forms)

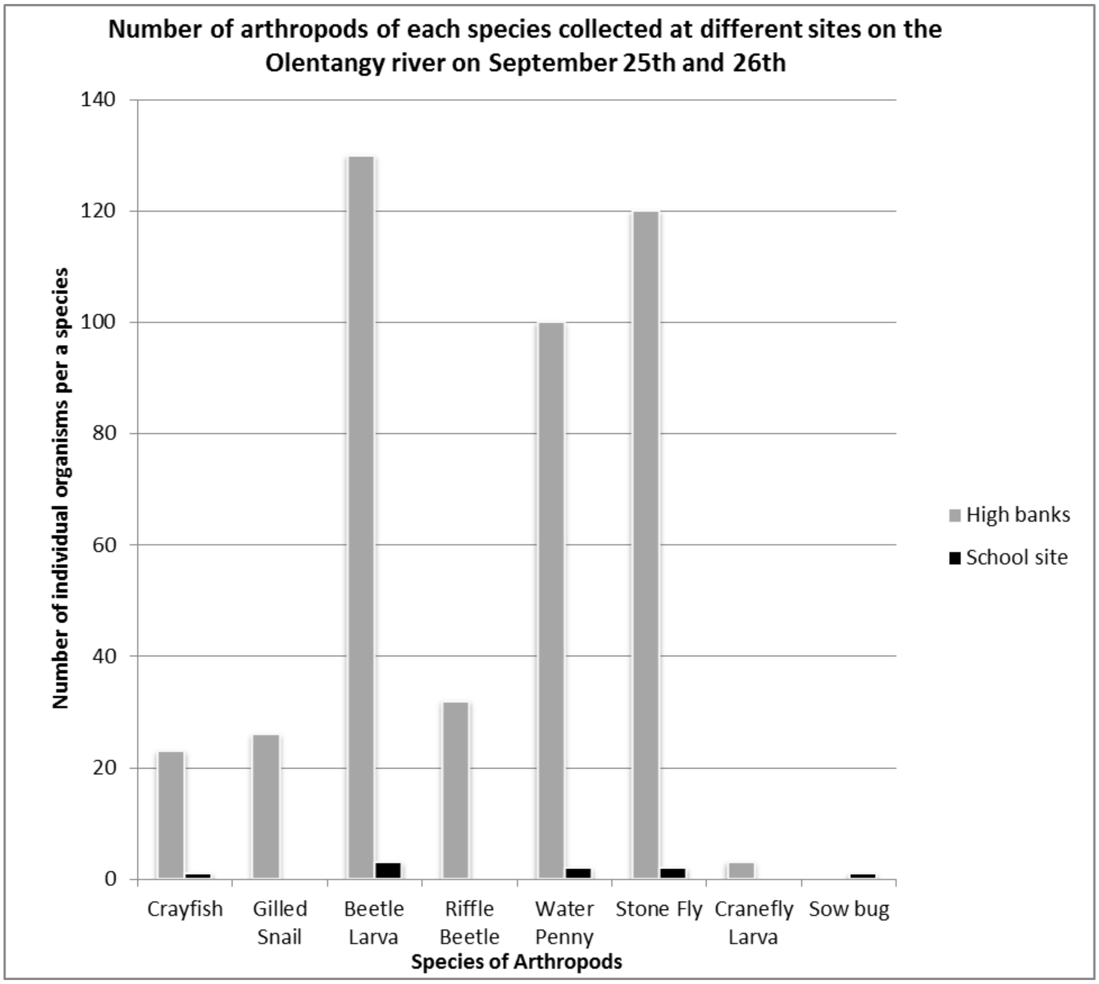


Figure 4. This graph shows the number of organisms collected of various species of arthropods from two locations on the Olentangy River. The data from the graph shows that there is a significant difference in the abundance of organisms in the various locations. Only five species of arthropods were observed at school site while seven species of arthropods were observed from the High banks site. Also, the number of organisms found at the school site is far less than the number of organisms found at the Highbanks site. This significant difference shows that there are many aspects about the school site location that inhibit life.

Highbanks Arthropods				
	Species number	Number found	P_i	$P_i \ln(P_i)$
Crayfish	1	23	0.053	-0.1557
Gilled Snail	2	26	0.0599	-0.1686
Beetle Larva	3	130	0.2995	-0.3611
Riffle Beetle	4	32	0.0737	-0.1922
Water Penny	5	100	0.2304	-0.3382
Stone Fly	6	120	0.2765	-0.3555
Crane fly Larva	7	3	0.0069	-0.0343
Total:	7 species	434		-1.6056
H = -1.6056 * -1 = **1.6056**				

Table 1. Arthropod data for Highbanks site. Note that P_i is the proportion of individuals in the sample, calculated by dividing the number of a particular species found by the total number of samples collected.

School Site Arthropods				
	Species number	Number found	P_i	$P_i \ln(P_i)$
Crayfish	1	1	0.1111	-0.2441
Beetle Larva	3	3	0.3333	-0.3662
Water Penny	5	2	0.2222	-0.3342
Stone Fly	6	2	0.2222	-0.3342
Sow bug	12	1	0.1111	-0.2441
Total:	5 species	9		-1.5228
H = -1.5228 * -1 = **1.5228**				

Table 2. Arthropod data for school site. Note that P_i is the proportion of individuals in the sample, calculated by dividing the number of a particular species found by the total number of samples collected.

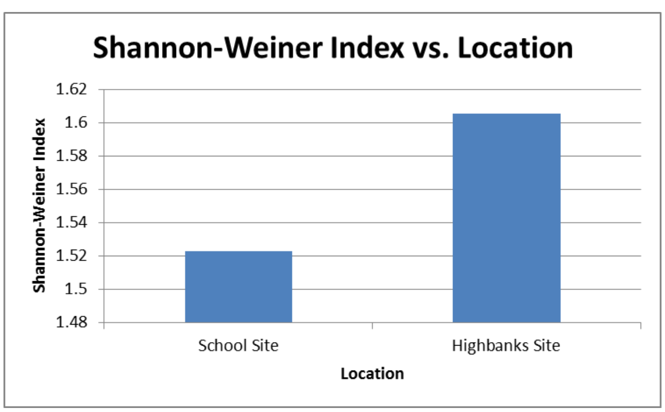


Figure 5. Shannon-Weiner Index vs. location.

CONCLUSIONS:

This investigation was conducted to show the differences in biodiversities between two locations on the Olentangy River. It was hypothesized that the second location (school site) would have a lower biodiversity because of the slow flow and depth of the water. The results from this study confirmed the hypothesis. The Shannon-Weiner index for the High Banks site was calculated to be 1.6056 while the Shannon-Weiner index for the school site was calculated to be 1.5228. As the index gets higher, it becomes more and more accurate to predict the probability of selecting an individual out of all other organisms. Therefore, a high index means that the accuracy of predicting the probability of selecting a particular individual out of a whole is higher and the diversity of the whole is greater. This means the higher the index, the more diverse the ecosystem is. Based on the index, the first site is more diverse and more ecologically sound while the second site is less diverse, thereby supporting the hypothesis.

Much less life was found in the second site for many reasons. At first glance, the water appeared stagnant. Around 95% of the school site was classified as a pool. Slow water movement allows for muck to settle on the substrate. The presence of muck on the substrate greatly reduces the ability of organisms to survive on the substrate because the crevices in which they usually reside are covered over. In addition to the loss of habitat, muck also provides a good habitat for bacteria that consumes a relatively large amount of oxygen. The presence of these bacteria lowers the dissolved oxygen concentration of the water and makes it more difficult for various organisms to reside. Riffle zones are healthy for water communities because the mixing of water and air allows for a greater dissolved oxygen concentration. This is something that was absent in the second site, but observed in the first location. When the state route 315 was constructed, the Olentangy River was straightened. This human intervention caused many changes to the ecosystems. The straightening of the river caused a loss of shore line and therefore a loss of sediment that nourishes ecosystems. Moreover, this practice of channelization makes the river more prone to erosion. In addition, pollution is clearly evident in the school site portion of the river because it is not a part of a protected park. Also, the second site was much deeper than the first site. Less sunlight reached the bottom of the second site than the first also contributing to fewer organisms and less biodiversity. A considerable amount of silt was noted in the school site. Silt decreases the dissolved oxygen level and availability of food in the water, resulting in a loss of life.

There were many drawbacks to this study. For instance, the sunlight, water temperature, and time of sampling were not recorded. The water temperature rose as the day went on and it may be true that some organisms do not come outside in the heat or vice versa. However, the water temperature cannot be controlled. An error that the experimenter made was not recording the location of samples in relation to sunlight (shadow or light). Some organisms are known to avoid light. A possible way to improve this experiment is to record the sunlight cover of sampling locations so that the results of the sunlight samples can be compared to the shadow samples to see if there is a correlating difference in biodiversity or prevalence of specific species. Another experiment could be to measure the toxicity and pH levels of both sites to see if that might be inhibiting the life at the school site as well.

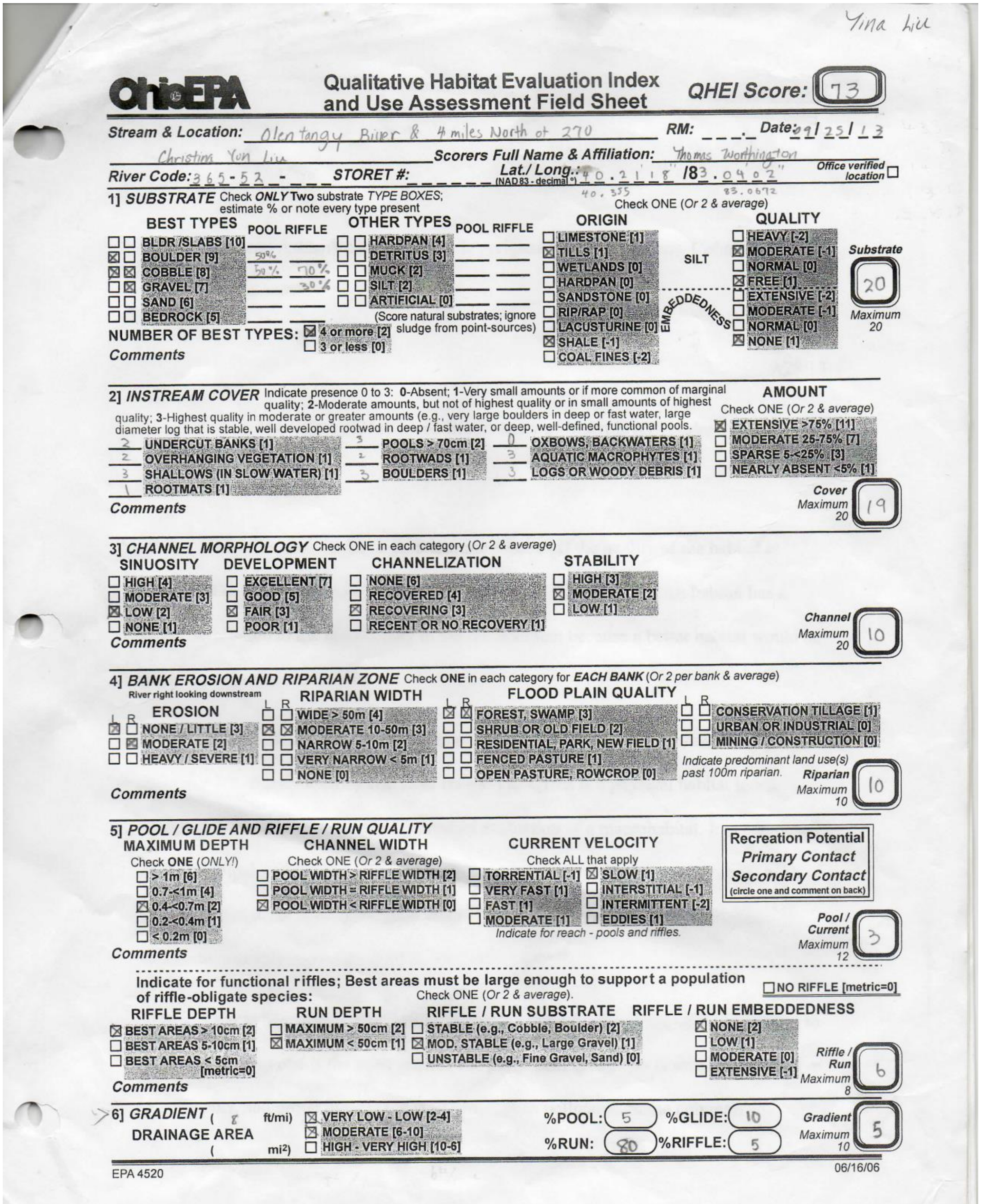
WORKS CITED:

Taft BT, Koncelik JK. 2006 June. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI) [Internet]. 2006. Columbus(OH):Ohio EPA; [2006 June, cited 2013 Nov 12] . Available from: http://www.epa.state.oh.us/portals/35/documents/qheimanualjune2006.pdf

Shannon - Wiener Diversity Index. Bumperscollege [Internet]. [cited 2013 November 12] . Available from: http://bumperscollege.uark.edu/west/3103/08diversityexercise.htm

APPENDIX:

QHEI forms, or Qualitative Habitat Evaluation Index reports, are a means of transforming qualitative observations into quantitative observations. The measure of qualitative habitats corresponds to the physical feathures that exist in the particular habitats. The QHEI forms are divided into several categories, each assesing an individual component in an ecosystem. Points are allocated for various features depending on their known affect on ecosystems. The sum of the points is the QHEI score.



Yina Liu

Ohio EPA — **Qualitative Habitat Evaluation Index and Use Assessment Field Sheet** — **QHEI Score:** 73

Stream & Location: Olentangy River & 4 miles North of 270 — RM: ___ . ___ Date: 09/25/13

Christina Yon Liu — Scorers Full Name & Affiliation: Thomas Worthington

River Code: 365-52-___ STORET #: ______ Lat./Long. (NAD 83 - decimal °): 40.2118 / 83.0402 — Office verified location ☐

1] SUBSTRATE Check ONLY Two substrate TYPE BOXES; estimate % or note every type present. Check ONE (Or 2 & average)

BEST TYPES	POOL	RIFFLE	OTHER TYPES	POOL	RIFFLE	ORIGIN	QUALITY
☐☐ BLDR /SLABS [10]			☐☐ HARDPAN [4]			☐ LIMESTONE [1]	☐ HEAVY [-2]
☒☐ BOULDER [9]	50%		☐☐ DETRITUS [3]			☒ TILLS [1]	☒ MODERATE [-1]
☒☒ COBBLE [8]	50%	70%	☐☐ MUCK [2]			☐ WETLANDS [0]	☐ NORMAL [0]
☐☒ GRAVEL [7]		30%	☐☐ SILT [2]			☐ HARDPAN [0]	☒ FREE [1]
☐☐ SAND [6]			☐☐ ARTIFICIAL [0]			☐ SANDSTONE [0]	☐ EXTENSIVE [-2]
☐☐ BEDROCK [5]						☐ RIP/RAP [0]	☐ MODERATE [-1]
						☐ LACUSTURINE [0]	☐ NORMAL [0]
						☒ SHALE [-1]	☒ NONE [1]
						☐ COAL FINES [-2]	

(Score natural substrates; ignore sludge from point-sources). SILT / EMBEDDEDNESS

NUMBER OF BEST TYPES: ☒ 4 or more [2] ☐ 3 or less [0]

Comments — Substrate: 20 (Maximum 20)

2] INSTREAM COVER Indicate presence 0 to 3: 0-Absent; 1-Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

2 UNDERCUT BANKS [1]; 2 OVERHANGING VEGETATION [1]; 3 SHALLOWS (IN SLOW WATER) [1]; 1 ROOTMATS [1]; 3 POOLS > 70cm [2]; 2 ROOTWADS [1]; 3 BOULDERS [1]; 0 OXBOWS, BACKWATERS [1]; 3 AQUATIC MACROPHYTES [1]; 3 LOGS OR WOODY DEBRIS [1]

AMOUNT — Check ONE (Or 2 & average): ☒ EXTENSIVE >75% [11] ☐ MODERATE 25-75% [7] ☐ SPARSE 5-<25% [3] ☐ NEARLY ABSENT <5% [1]

Comments — Cover: 19 (Maximum 20)

3] CHANNEL MORPHOLOGY Check ONE in each category (Or 2 & average)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
☐ HIGH [4]	☐ EXCELLENT [7]	☐ NONE [6]	☐ HIGH [3]
☐ MODERATE [3]	☐ GOOD [5]	☐ RECOVERED [4]	☒ MODERATE [2]
☒ LOW [2]	☒ FAIR [3]	☒ RECOVERING [3]	☐ LOW [1]
☐ NONE [1]	☐ POOR [1]	☐ RECENT OR NO RECOVERY [1]	

Comments — Channel: 10 (Maximum 20)

4] BANK EROSION AND RIPARIAN ZONE Check ONE in each category for EACH BANK (Or 2 per bank & average). River right looking downstream.

EROSION (L R)	RIPARIAN WIDTH (L R)	FLOOD PLAIN QUALITY (L R)	(L R)
☒☐ NONE / LITTLE [3]	☐☐ WIDE > 50m [4]	☒☒ FOREST, SWAMP [3]	☐☐ CONSERVATION TILLAGE [1]
☐☒ MODERATE [2]	☒☒ MODERATE 10-50m [3]	☐☐ SHRUB OR OLD FIELD [2]	☐☐ URBAN OR INDUSTRIAL [0]
☐☐ HEAVY / SEVERE [1]	☐☐ NARROW 5-10m [2]	☐☐ RESIDENTIAL, PARK, NEW FIELD [1]	☐☐ MINING / CONSTRUCTION [0]
	☐☐ VERY NARROW < 5m [1]	☐☐ FENCED PASTURE [1]	
	☐☐ NONE [0]	☐☐ OPEN PASTURE, ROWCROP [0]	

Indicate predominant land use(s) past 100m riparian.

Comments — Riparian: 10 (Maximum 10)

5] POOL / GLIDE AND RIFFLE / RUN QUALITY

MAXIMUM DEPTH (Check ONE (ONLY!))	CHANNEL WIDTH (Check ONE (Or 2 & average))	CURRENT VELOCITY (Check ALL that apply)	
☐ > 1m [6]	☐ POOL WIDTH > RIFFLE WIDTH [2]	☐ TORRENTIAL [-1]	☒ SLOW [1]
☐ 0.7-<1m [4]	☐ POOL WIDTH = RIFFLE WIDTH [1]	☐ VERY FAST [1]	☐ INTERSTITIAL [-1]
☒ 0.4-<0.7m [2]	☒ POOL WIDTH < RIFFLE WIDTH [0]	☐ FAST [1]	☐ INTERMITTENT [-2]
☐ 0.2-<0.4m [1]		☐ MODERATE [1]	☐ EDDIES [1]
☐ < 0.2m [0]			

Indicate for reach - pools and riffles.

Recreation Potential: Primary Contact / Secondary Contact (circle one and comment on back)

Comments — Pool / Current: 3 (Maximum 12)

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species: Check ONE (Or 2 & average). ☐ NO RIFFLE [metric=0]

RIFFLE DEPTH	RUN DEPTH	RIFFLE / RUN SUBSTRATE	RIFFLE / RUN EMBEDDEDNESS
☒ BEST AREAS > 10cm [2]	☐ MAXIMUM > 50cm [2]	☐ STABLE (e.g., Cobble, Boulder) [2]	☒ NONE [2]
☐ BEST AREAS 5-10cm [1]	☒ MAXIMUM < 50cm [1]	☒ MOD. STABLE (e.g., Large Gravel) [1]	☐ LOW [1]
☐ BEST AREAS < 5cm [metric=0]		☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]	☐ MODERATE [0]
			☐ EXTENSIVE [-1]

Comments — Riffle / Run: 6 (Maximum 8)

6] GRADIENT (8 ft/mi) ☒ VERY LOW - LOW [2-4] ☒ MODERATE [6-10] ☐ HIGH - VERY HIGH [10-6]

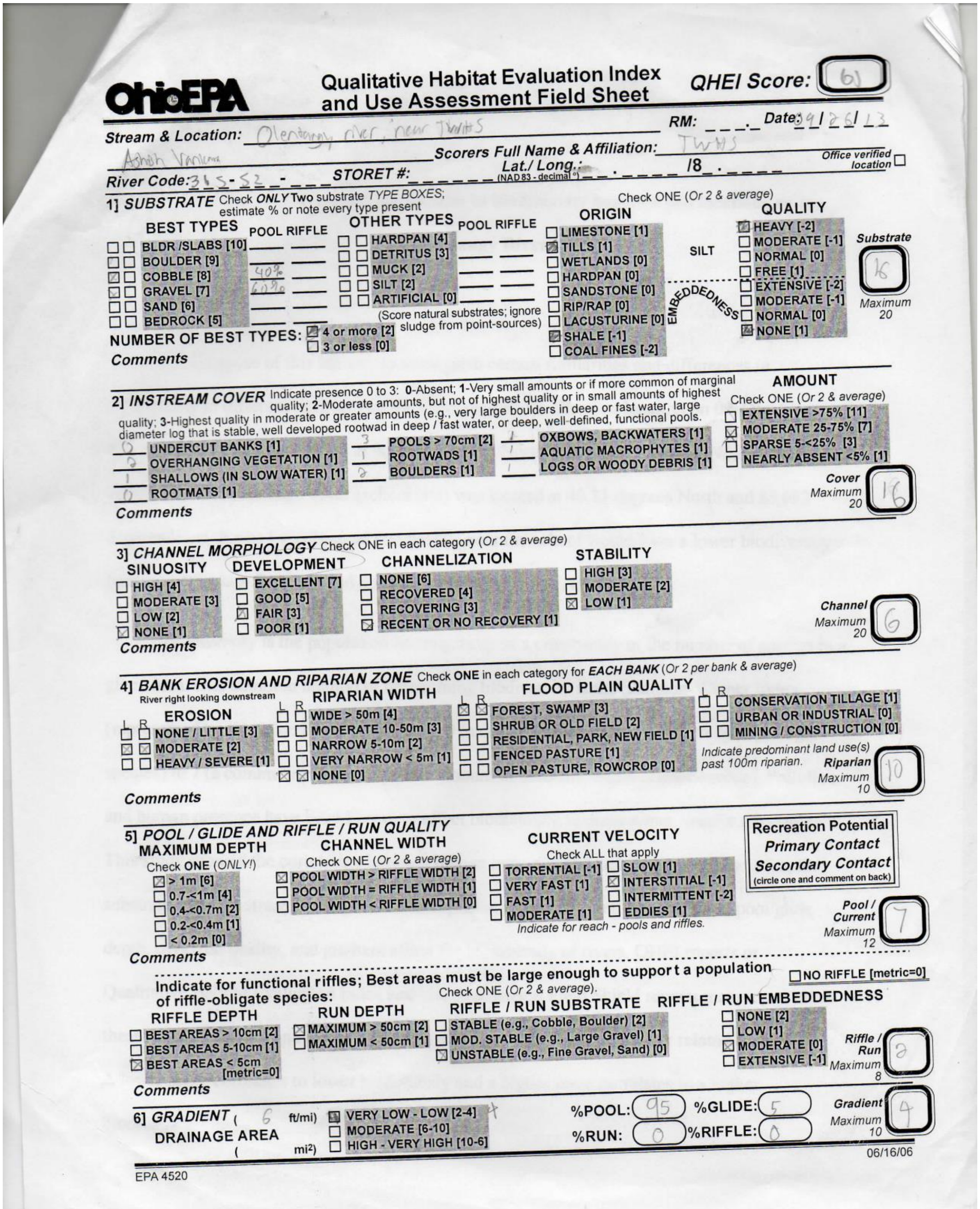
DRAINAGE AREA (mi²)

%POOL: 5 %GLIDE: 10 %RUN: 80 %RIFFLE: 5

Gradient: 5 (Maximum 10)

EPA 4520 — 06/16/06

Figure 6. Highbanks site QHEI form.



OhioEPA Qualitative Habitat Evaluation Index and Use Assessment Field Sheet — QHEI Score: 61

Stream & Location: Olentangy river, near TWHS — RM: ___.__ Date: 9/26/13

Ashish Vankina — Scorers Full Name & Affiliation: TWHS — Office verified location ☐

River Code: 31 5 - 52 - ___ STORET #: ___ Lat./Long.: (NAD 83 - decimal °) __.____ /8_.____

1] SUBSTRATE Check ONLY Two substrate TYPE BOXES; estimate % or note every type present. Check ONE (Or 2 & average)

BEST TYPES	POOL	RIFFLE	OTHER TYPES	POOL	RIFFLE	ORIGIN	QUALITY
☐☐ BLDR /SLABS [10]			☐☐ HARDPAN [4]			☐ LIMESTONE [1]	☒ HEAVY [-2] (SILT)
☐☐ BOULDER [9]			☐☐ DETRITUS [3]			☒ TILLS [1]	☐ MODERATE [-1]
☒☐ COBBLE [8]	40%		☐☐ MUCK [2]			☐ WETLANDS [0]	☐ NORMAL [0]
☒☐ GRAVEL [7]	60%		☐☐ SILT [2]			☐ HARDPAN [0]	☐ FREE [1]
☐☐ SAND [6]			☐☐ ARTIFICIAL [0]			☐ SANDSTONE [0]	☐ EXTENSIVE [-2] (EMBEDDEDNESS)
☐☐ BEDROCK [5]			(Score natural substrates; ignore sludge from point-sources)			☐ RIP/RAP [0]	☐ MODERATE [-1]
						☐ LACUSTURINE [0]	☐ NORMAL [0]
						☒ SHALE [-1]	☒ NONE [1]
						☐ COAL FINES [-2]	

NUMBER OF BEST TYPES: ☒ 4 or more [2] ☐ 3 or less [0]

Comments — Substrate 16 (Maximum 20)

2] INSTREAM COVER Indicate presence 0 to 3: 0-Absent; 1-Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

			AMOUNT Check ONE (Or 2 & average)
0 UNDERCUT BANKS [1]	3 POOLS > 70cm [2]	1 OXBOWS, BACKWATERS [1]	☐ EXTENSIVE >75% [11]
2 OVERHANGING VEGETATION [1]	1 ROOTWADS [1]	1 AQUATIC MACROPHYTES [1]	☒ MODERATE 25-75% [7]
1 SHALLOWS (IN SLOW WATER) [1]	2 BOULDERS [1]	1 LOGS OR WOODY DEBRIS [1]	☐ SPARSE 5-<25% [3]
0 ROOTMATS [1]			☐ NEARLY ABSENT <5% [1]

Comments — Cover 16 (Maximum 20)

3] CHANNEL MORPHOLOGY Check ONE in each category (Or 2 & average)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
☐ HIGH [4]	☐ EXCELLENT [7]	☐ NONE [6]	☐ HIGH [3]
☐ MODERATE [3]	☐ GOOD [5]	☐ RECOVERED [4]	☐ MODERATE [2]
☐ LOW [2]	☒ FAIR [3]	☐ RECOVERING [3]	☒ LOW [1]
☒ NONE [1]	☐ POOR [1]	☒ RECENT OR NO RECOVERY [1]	

Comments — Channel 6 (Maximum 20)

4] BANK EROSION AND RIPARIAN ZONE Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)	RIPARIAN WIDTH (L R)	FLOOD PLAIN QUALITY (L R)	(L R)
☐☐ NONE / LITTLE [3]	☐☐ WIDE > 50m [4]	☒☒ FOREST, SWAMP [3]	☐☐ CONSERVATION TILLAGE [1]
☒☒ MODERATE [2]	☐☐ MODERATE 10-50m [3]	☐☐ SHRUB OR OLD FIELD [2]	☐☐ URBAN OR INDUSTRIAL [0]
☐☐ HEAVY / SEVERE [1]	☐☐ NARROW 5-10m [2]	☐☐ RESIDENTIAL, PARK, NEW FIELD [1]	☐☐ MINING / CONSTRUCTION [0]
	☐☐ VERY NARROW < 5m [1]	☐☐ FENCED PASTURE [1]	Indicate predominant land use(s) past 100m riparian.
	☒☒ NONE [0]	☐☐ OPEN PASTURE, ROWCROP [0]	

Comments — Riparian 10 (Maximum 10)

5] POOL / GLIDE AND RIFFLE / RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)	CHANNEL WIDTH Check ONE (Or 2 & average)	CURRENT VELOCITY Check ALL that apply	
☒ > 1m [6]	☒ POOL WIDTH > RIFFLE WIDTH [2]	☐ TORRENTIAL [-1]	☐ SLOW [1]
☐ 0.7-<1m [4]	☐ POOL WIDTH = RIFFLE WIDTH [1]	☐ VERY FAST [1]	☒ INTERSTITIAL [-1]
☐ 0.4-<0.7m [2]	☐ POOL WIDTH < RIFFLE WIDTH [0]	☐ FAST [1]	☐ INTERMITTENT [-2]
☐ 0.2-<0.4m [1]		☐ MODERATE [1]	☐ EDDIES [1]
☐ < 0.2m [0]		Indicate for reach - pools and riffles.	

Recreation Potential: Primary Contact / Secondary Contact (circle one and comment on back)

Comments — Pool / Current 7 (Maximum 12)

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species: Check ONE (Or 2 & average). ☐ NO RIFFLE [metric=0]

RIFFLE DEPTH	RUN DEPTH	RIFFLE / RUN SUBSTRATE	RIFFLE / RUN EMBEDDEDNESS
☐ BEST AREAS > 10cm [2]	☒ MAXIMUM > 50cm [2]	☐ STABLE (e.g., Cobble, Boulder) [2]	☐ NONE [2]
☐ BEST AREAS 5-10cm [1]	☐ MAXIMUM < 50cm [1]	☐ MOD. STABLE (e.g., Large Gravel) [1]	☐ LOW [1]
☒ BEST AREAS < 5cm [metric=0]		☒ UNSTABLE (e.g., Fine Gravel, Sand) [0]	☒ MODERATE [0]
			☐ EXTENSIVE [-1]

Comments — Riffle / Run 2 (Maximum 8)

6] GRADIENT (6 ft/mi) ☒ VERY LOW - LOW [2-4] 4 ☐ MODERATE [6-10] ☐ HIGH - VERY HIGH [10-6]

DRAINAGE AREA (mi²)

%POOL: 95 %GLIDE: 5 %RUN: 0 %RIFFLE: 0 — Gradient 4 (Maximum 10)

EPA 4520 — 06/16/06

Figure 7. School site QHEI form.

THE EFFECTS OF THE GENE OR2J3 ON ONE'S NASAL SENSE, ABILITY TO SMELL CIS-3-HEXAN-1-OL (C3HEX), AND PREFERENCE FOR TOMATOES

Marissa Licata, Jordyn Coyne, Amanda DeFeo, St. Dominic High School, Oyster Bay, NY
Dr. Bruce Nash, Cold Spring Harbor DNA Learning Center, Cold Spring Harbor, NY

ABSTRACT:

We believe that the gene OR2J3 may be responsible for a person's food preference. To test our theory we conducted different "smell trials" with our subjects using the chemical cis-3-hexen-1-ol (C3HEX). The gene OR2J3 allows a person to encode the protein olfactory receptor 2J3 and smell the grassy, green aroma of C3HEX. C3HEX is naturally found in tomatoes, leading us to theory that individuals that contain the gene OR2J3 would have a preference towards tomatoes. Extracting and sequencing DNA was done to analyze individual's genes and search for polymorphisms that potentially could restrict one's ability to smell the aroma. Those that had difficulty in smelling C3HEX in different concentrations would most likely not contain the gene, OR2J3. Our results had shown the majority of our test group did contain the gene OR2J3, while the others had a polymorphism that obstructed their ability to smell. There was a small correlation between the gene and preference towards tomatoes. However, results may have been varied due to personal choice.

INTRODUCTION:

Our sense of smell is very influential in our lives. The way we perceive odors dictates the way we taste. When we taste food, odor molecules travel through the passage to their odor receptor. Then, messages are sent to your brain, which identifies the way the food will taste[i]. Our genes play an important role in our body in determining traits. These traits can range from various physical traits, and possibly determine a person's food preference.

C3HEX is a chemical that has evidence of being correlated with the gene OR2J3 to allow a person to experience a "grassy" smell. For that reason, C3HEX can be found in a variety of foods to give the "grassy" effect on the consumers.[ii] One food in particular that C3HEX is known to be present in is tomatoes. The knowledge of the OR2J3 gene being related to a person's ability to smell this brought the question, "If a person is able to smell the attractive, grassy smell of a tomato because they possess the OR2J3 gene; will that person be more likely to prefer tomatoes over a person who does not possess the OR2J3 gene?

The OR2J3 gene can be found on chromosome 6p22.[iii] It must be clarified that claiming the gene OR2J3 is solely responsible for the ability to smell the chemical C3HEX is invalid.

Concentrated C3HEX gives a very distinct, strong grass smell that every person without any nasal deficiencies should be able to detect. It is being claimed those who possess the gene OR2J3 will be more likely to detect the smell at lower concentrations. There has also been evidence to support that at a certain threshold C3HEX is no longer able to be detected in a smell trial, but resulted with a haplotype of OR2J3 being able to explain the difference between the thresholds.[iv]

In order to sequence DNA to determine if this gene is present, a tool call DNA Subway is used to perform this task. DNA Subway uses the concept of a subway lines to compare DNA sequences. DNA subway simplifies the task by breaking up each step in simple directions, which results with understandable, easy results. DNA Subway is available to any students and faculty who are interested in genomic analysis. [v]

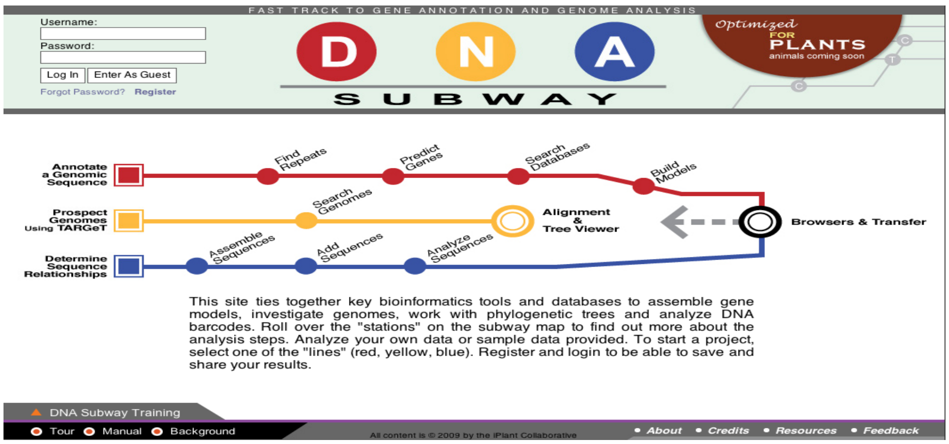


Figure 1. Screenshot of DNA Subway website. It demonstrates the basic set up of DNA subway and give a visual image of the subway concept. The figure also shows how each step of the genomic analysis is broken up and the process of each "subway line." [vi]

MATERIALS AND METHODS

The experiment commenced with the discovery of the primers, in humans, for the odor receptor OR2J3. Once the primers were known, DNA was taken from all subject using a saline rinse. 10 mL of 9% saline was rinsed inside the mouth for 1 minute and placed back into the cup. 1000 μL of rinsed saline mixture was taken into a centrifuge tube at top speed for 1 minute. 100μL of the mixture was taken to re-suspend the pellet. 30 μL of the re-suspended mixture was place in chelex tubes. The chelex tubes were boiled at 99°C for 10 minutes. The tubes were then placed in adapters and centrifuged for 1 minute. The DNA was coded to ensure confidentiality. PCR tubes containing Ready-To-Go beads were used. 18μLof primer/ loading dye mixes were added to each tube and dissolved for 1 minute. Then 2μL of DNA from each chelex tube was added to the PCR tubes. The samples were then placed in a thermal cycler programmed for 35 cycles at 51°C. Once the thermal cycling was completed, the samples were stored on ice. A normal agrose gel was performed for 30 minutes at 130V to verify the DNA.

Seven dilutions of C3HEX were created for the smell trials. The dilutions included: 38.4 ppm 19.2 ppm, 9.6 ppm, 4.8 ppm, 2.4 ppm, 1.2 ppm, 0.6 ppm, and 0.3 ppm[vii]. Double bind tests were commenced to the subjects and surveys were then given to all subjects, which indicated the reaction from each smell trial and also described their food preference. The data from these surveys were documented and also coded to protect the identity of the subjects.

The verified DNA samples were then sent to Gene Wiz to be sequenced. A basepair substitution responsible for the inability to smell C3HEX was discovered on ALFRED. This sequence was then used to detect any differences found in the subjects' DNA sequences.

HYPOTHESIS:

If a person that has the odor receptor, OR2J3, then they will be able to easily detect the grassy, green aroma of cis-3-hexen-1-ol. Furthermore, if the person contains the odor receptor, then this person will have a preference towards tomatoes.

DATA AND RESULTS:

The data we collected was comprised of the genetic and bioinformatics aspect of the saline rinse results and the survey results. The amplified forward and reverse DNA samples were then compared and indicated which sequences contained a polymorphism. Our data, consisted of eight samples (four samples done twice). In addition to these samples, the sequence for polymorphisms of the gene OR2J3 (known to be responsible for not being able to smell C3HEX) was also included with the data analyzed on DNA Subway. One sample in test group had proven to contain the OR2J3 polymorphism. After we compared this sample to the corresponding survey, the person was sampled specified they did not have a preference for tomatoes. The survey from the smell trials also determined this subject also had difficulty smelling C3HEX at lower concentrations, compared to other subjects possessing the gene. This discovery had supported our hypothesis.

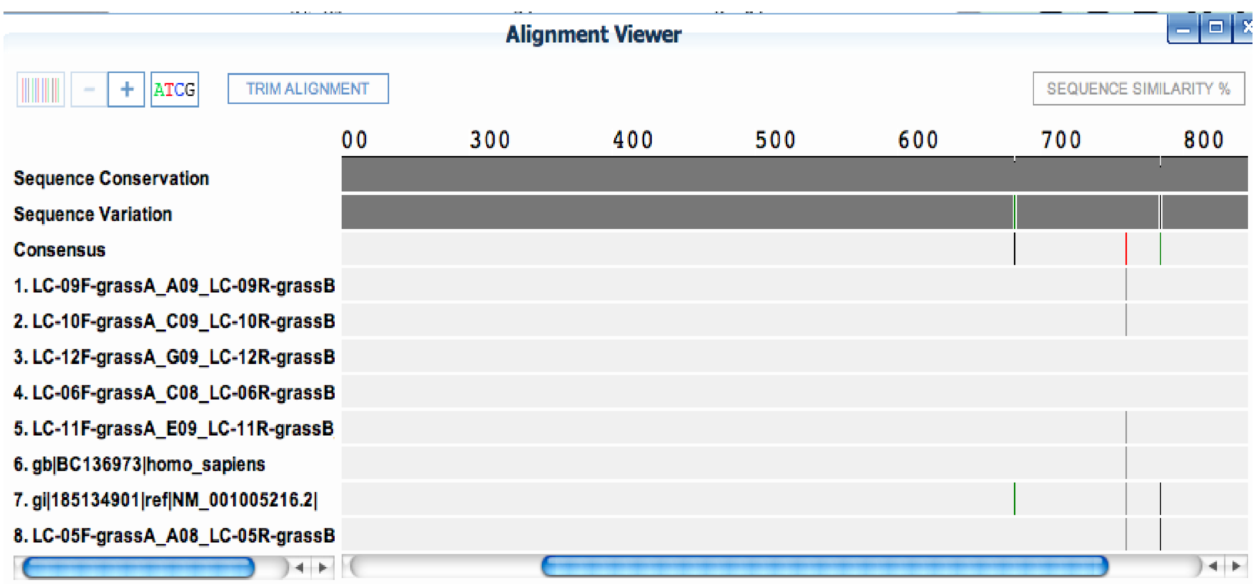


Figure 2. A screenshot of the DNA sequences from our experiment that were examined using DNA Subway.

CONCLUSIONS:

Our hypothesis was supported by our results. Our theory that food preference has some correlation with possessing the gene OR2J3 was supported by our data. Our data had determined that the gene OR2J3 would be able to smell the “grassy” aroma of C3HEX, while those that had the polymorphism would not be able to detect the “grassy” as well as others. The food preference aspect of our hypothesis had faced other factors. While some of data agreed with our hypothesis, some subjects in the test group did not have a preference for tomatoes but did possess the gene OR2J3. It is believed that this other factors affecting our results, such as food texture. For example a person may be attracted to smell of a certain food but if that food has an undesirable texture, it will cause that person to not have a preference towards it.

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