Cell Biology Invention Activity Handouts

The following handouts are an accompaniment to the "Invention Activities for University Cell Biology - A Guide for Instructors" by Jared L. Taylor, August 2010.

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Note: the activities on the following pages are designed to be printed on legal size paper (8.5x14 inches) and as such the page format in this file is set to legal size.

Name: _____ Name:_____

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Invention – Rodent Zoo Exhibits

You are in charge of creating new rodent exhibits for a zoo. The exhibits consist of two glass rooms (of equal size) which are separated by a single wall that runs floor to ceiling. Two types of rodents will be housed in these exhibits, as shown on the screen.

Consider the exhibits that are also shown on the screen. Each exhibit has two conditions that must be fulfilled at all times (not just during feeding time, for example). You need to design a separating wall to allow one type of rodent to pass from room to room while preventing another type of rodent from passing through. Also, for the purposes of this activity you can assume the following:

- The dimensions for each rodent are consistent (i.e. all the mice are the same size and mass).
- The movement of each rodent is essentially constant (i.e. they are always running around).
- The rodents move independently of each other (i.e. they don't follow each other).

Design the wall in for each exhibit (the walls can be different in each exhibit) to fulfill the requirements shown on the screen for each exhibit. Note that you are free to be creative in modifying each wall, but you are not permitted to redesign anything else about the exhibits. The rodents must not be harmed by your invention. NOTE: you should make your wall designs to be as simple as possible (simple meaning the cheapest to design, build, and operate).

Draw a diagram for each wall design you come up with, and add any necessary explanation.

Name: _____ Name:_____

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Invention – Chain Machine

Part I

You are a design engineer for a company that produces special chains of large plastic objects and magnets. These chains are used in ships as spacers between the inner and outer hulls and are extremely valuable. The current machine being used to make these chains efficiently connects one piece to the others (magnets and plastic) along the nylon rope. But this is all it can do, requiring someone to manually feed the components into the machine in the correct order (boring and slow).

You are given the job of redesigning the machine to scale up production. The machine needs to be able to mass produce the chains with the following conditions:

- The machine must be able to mass produce different chains for ships, although it only needs to produce one type of chain at a time.
- The machine must be able to select the types of pieces and link them in the correct order.
- The machine must link the magnets in the correct orientation.
- The machine must be purely mechanical in nature (no electronics or computers).

Your job is to redesign the machine so that it can mass produce any chain design. You are free to be as creative as you like as long as your design satisfies the conditions outlined above. You are not permitted to change the chain designs or change the types of pieces used.

***Part II* (only attempt this once Part 1 is complete)**

A customer that has purchased a large number of different chains send them back to have them fitted with special casings, which are designed to fit three adjacent chain pieces (an example will be shown on the screen). These casings must match the chains in both shape and magnet polarity. If we assume that the two halves of the casing shown on the screen make up ONE whole casing, how many different casings are possible? The casing always fits the chains in groups of three chain pieces.

Can you think of a way a second machine could correctly choose and fit the casings to the chains?

Name: _____ Name:_____

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Invention – Controlling the Chain Machine

Part I

Thanks to your recent redesign break-through, your company has had great success in mass producing the magnet chains that are used for ship construction. After analyzing the market, it has become clear that the company would be most profitable by concentrating on the production of its two best selling chains.

Chain Type A uses Type A magnets, and demand is so high that the company can sell these chains as quickly as they are made. Chain Type B uses Type B magnets, and does not sell as quickly as Chain Type A, but is still profitable.

The supply of both magnet types fluctuates (and is often limited), and the machine can only be configured to produce one type of chain at any given time. As such, it is important to closely control which type of chain is produced in order to increase efficiency and profits. Note that the plastic pieces used are easily obtained and their supply is not limited. Also, recall that the new machine uses a unique template for each type of chain that is produced, and the templates need to be switched when a different chain type is needed.

Your company assigns you with the task of further redesigning the manufacturing process, this time with the control system of the machine. In particular, the control system must do the following:

1. If only Type A magnets are available, the machine must produce Chain Type A.
2. If both types of magnets are available, the machine must produce Chain Type A.
3. If only Type B magnets are available, then machine must produce Chain Type B.

Your job is to redesign the control mechanism of the machine so that it follows the above three rules. In particular, the machine must be able to switch (as quickly as possible) the templates and produce the correct type of chain based upon the supply of the magnets. As with the previous activities, your solution must be mechanical in nature, and cannot use electronics or computers. As before, you can add anything that would be useful to the inner workings of the machine, or as an external component of the machine.

Parts II and III will be shown on the screen.

Name: _____ Name:_____

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Invention – Railway Safety and Repair

Part I

You are a safety engineer for a high-speed railway company that has been contracted to lay a high-speed railroad track system across Canada. The rails used in such systems must be meticulously installed and maintained in order to prevent derailments. There are two types of rail damage that must be located and repaired immediately.

- Rail gaps can occur during construction if a shorter piece of rail is accidentally used (rare, but it does happen). At high speeds, the train wheels can be damaged from these gaps and the trains can derail. Even spaces as small as 1 cm in length are dangerous.
- Rail warping occurs when the rails bend outwards (or inwards) slightly. These warps can sometimes be hundreds of metres long, and allow the train to shift side to side. At the high speeds the train travels, even shifts of 1 cm can cause problems.

Invent a device that can travel along the tracks and identify any rails that need replacing by a repair team. Note that in order to save money, only the damaged rails must be replaced. This means that for gaps, the device must know which rail is shorter. For warps, the device must be able to tell when the warping begins and ends, and on which side it occurs.

Part II

To complicate things further, there are three types of rails used, each made of a different alloy (A, B, and C). The different alloys have different strength properties and are used in specific places along the track. They must always match up so that a type A rail is always paired with a type A rail across from it, B across from B, and C across from C.

In order to identify the type, each rail must be marked in some way before being used along the track (you are free to decide how this marking works). This also means the device in *Part I* must be able to identify the type of rail needed for repairs so that the repair team brings the correct types of rails. Neither the device nor the repair team carries blueprints for the entire track.

There also needs to be a back-up system to check the repairs and ensure that all new rails are of the right type (i.e. type A is only placed across from type A).

Invent a back-up system to check the work of repair team. Note that if it finds a mismatch, it must be able to identify which side is incorrect and which side is correct so that the repair team can make the proper correction (the repair team does not keep records on which rails they replace).

Also consider the following questions:

- What happens if your device finds a rail that it can't identify?
- What happens if the damaged rails are part of a bend in the track?
- Imagine an earthquake hits part of the track and rails on both sides are completely lost. How could this be handled?

Name: _____ Name:_____

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Invention – Rubber Ducky

Part I

You run a carnival betting game which uses a circular pool, about 15 feet across, on which 200 small rubber ducks are floating. The ducks are gathered together in the center of a pool in a small ring enclosure that can be lowered to allow the ducks to float freely on the water. The ducks are all numbered, and people pay to place a bet on which duck will reach the edge of the pool first.

The game is a success and you make great money doing it. However, you find that collecting the ducks back in the center is both boring and time consuming, and you decide to design a way to have this done automatically.

Invent two different mechanisms that would cause the ducks to gather (or be gathered) in the center of the pool once the game is complete with minimal effort on your part. You are free to redesign any part of the system except for the main pool (has to be a circular 15 foot pool with water) and the number of ducks. WARNING: whatever you invent MUST NOT prohibit the ducks from floating freely and randomly once the game starts!

Part II (make sure you finish Part I first)

Your inventions from Part I work well, but you want to minimize the costs of powering them. You decide that the people standing around the side of the pool watching the game are a free source of energy…you just need to figure out a way to harness that energy without them knowing (people generally don't like being taken advantage of).

Invent a way to have the people gathered around the pool to help power your inventions in *Part I* without them knowing.

Name: _____ Name:_____

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Invention – Water Wheels

Mr. Jones decides to move to the interior of British Columbia to escape city life, and he settles in an area that does not have access to utilities. In order to have power and water, he digs a small stream from a nearby river to his house, as shown below. The water is used to drive a water wheel which powers a small generator. The water is also used for drinking, and for watering his crops (he grows his own food).

Mr. Jones enjoys his new life so much that his two friends, Mr. Calder and Mr. McTavish, also decide to move into the area, and each builds a house nearby. They also use the stream for power, drinking, and irrigation, as shown below.

Unfortunately, the three friends realise that the situation has some downfalls, especially for Mr. McTavish. When the power and water demands are high for all houses, there needs to be enough water in the stream to feed all three houses, otherwise Mr. McTavish (and possibly Mr. Calder) will be left dry.

On the other hand, when demands are low, too much water in the stream can cause flooding for any of the houses and crops. It is also important that the generators do not run when not needed (to prevent them from wearing out).

The three friends decide to design a control system to regulate the water as the demands of each house change. For example, the system must provide the correct amount of water flow to each house as shown in the table on the screen.

Keep in mind that in times of high or low rainfall the main river itself will have more or less water. However, you can assume that the main river always has some minimum amount of water in it and never runs dry.

Invent a system that will control the water flow to each of the houses and prevent flooding or water shortage. You can assume that there is electricity available from the generators in each house to power your invention. You can also assume that for each individual house, the demands for power and water increase and decrease together.

You are not permitted to change the overall plan of the water flow shown in the diagram (in other words, you must use the main stream with three independent parallel delivery streams for the houses).

Name: _____ Name:_____

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Invention – The Chain-Making Machine and Self-Folding Chains

You are a brilliant chemist who is experimenting with the surface chemistry of plastics, and you discover a way to change plastics so that they attract each other (but not repel). In fact, you even discover how to make different types of plastics that only attract themselves (i.e. a piece of plastic type A can attract another piece of plastic type A).

You decide to use these plastics to make various products, one of which is a flotation device that can be used on ships for people that fall overboard. By using the various attractive plastics that you have created, you are able to produce chains of plastic pieces that spontaneously fold into the desired shape.

You build a machine that can link these pieces of plastic together into chains which can then fold into the desired shape, as shown on the screen. The simple circle flotation device is suitable for one person. Some ship companies, however, ask you to produce devices for two and three people, as shown on the screen.

Invent a general manufacturing scheme that would allow you to make these devices using the least amount of different types of plastic pieces possible. Note that you are free to redesign any part of the above diagrams, except the shapes of the devices and the machine (it's only function is to link together the pieces of plastic that you feed into it).

Also, each attractive plastic piece only has enough "attractive force" to hold onto one other piece (i.e. only two pieces can stick together).

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Invention – Dragonflies

You have designed a mechanical dragonfly that has a miniature battery and can fly around for hours in a specially designed box that you made for them. The box contains 2000 of these mechanical dragonflies, and when their batteries are drained they land on the floor. This presents a challenge, because at times you need to locate a certain dragonfly in the box.

In order to make locating a dragonfly easier, you decide to design a "home base" for each dragonfly along the walls of the box (sort of a small shelf big enough for a single dragonfly to land). However, you don't have enough money to design a complex signal tracking system. Instead, the dragonflies fly randomly throughout the box and will randomly land on the home bases. You want to make the home base such that if the dragonfly lands on its own home base, it is able to physically recognize it as its home, and it stays there because some mechanism holds it in place. If the dragonfly lands on the wrong home base, it will not stay there and will fly off.

You need to figure out how to design the home base and how the dragonfly interacts with it so the interaction between the proper home base and dragonfly is specific. The same system must ensure that if a dragonfly lands on the wrong base it will quickly fly away

Note: to do this you need to consider how 'strong' the wings of the dragonflies are in comparison to the strength of the force holding it on a home base. That is, if a dragonfly lands on it own base, the strength of the force holding it there is greater than the strength of its wings (and therefore cannot lift off). On the other hand, if a dragonfly lands on the wrong home base, it wings need to be strong enough to overcome and attractive force from the base.