Understanding Car Crashes
When Physics Meets Biology

Teacher Organizer Answers

Video Concept Organizer

Part I: Pre-video inquiry
Directions: Before viewing the video, record your ideas about questions #1 and #2 below. Be prepared to discuss your responses with your partner(s) and the class.

1. Why is it that some spectacular race car crashes produce only minor injuries?

Answers will vary

2. How can three collisions occur in one crash between a car and a wall?

Answers will vary

Running time 24 minutes	Part II: During the video **Directions:** To help you remember the key science concepts discussed during the video, fill in the blanks or circle the correct answers.
01:36	What is the first scientific discipline that comes to mind when you think of car crashes? It's probably physics because Newton's laws of motion govern what happens to a vehicle in a crash. But if we want to understand the effects of a crash on a human body, we need look at what occurs when physical forces are applied to organs, tissues and cells, and this happens when physics meets biology in the field of injury biomechanics.
04:04	**History of crash research** Colonel John Stapp, a medical doctor and biophysicist in the United States Air Force, used himself as the test subject in his investigations of human tolerance to high *g* environments.
04:20	In one of his many tests, Dr. Stapp reached a speed of 632 miles per hour before one of the most powerful braking systems of all time stopped him in 1.4 seconds, subjecting him to more than 40 times the pull of gravity, or 40 *gs*.

Crash test dummy lab

05:12 These dummies behind me are a perfect example of combining **science, technology, engineering,** and **mathematics** to produce new **tools** that extend scientific understanding.

06:00

Family of dummies	Height (feet) [meters]		Weight (lbs) [mass in kg]	
95th percentile male	6' 2"	[1.88 m]	223 lbs	[101 kg]
5th percentile female	5'	[1.52 m]	107 lbs	[48.5 kg]
50th percentile male	5' 9"	[1.75]	172 lbs	[78.0kg]
CRABI - 6 month old	26.3"	[0.67 m]	17.3 lbs	[7.85 kg]

06:24 Side impact dummy: The accelerometers give us the ___acceleration___ of the mass. The load cell measures ___force___, and we have the potentiometers that measure the ____displacement____.

07:44 Biofidelity (circle *more* or *less*): The *more* or *less* biofidelic, the *more* or *less* like a human being it is in representing how it moves, what types of stresses it measures in the crash test, and then the true-to-lifeness of those measurements to the prediction of injury in a real person.

Crash anatomy

08:30 Let's start with some basic anatomy. The human body contains more than ___100 trillion___ cells. The body is structurally organized into four levels: __cells__, ___tissues___, ___organs___, and ____organ systems____.

The body contains four large, fluid-filled spaces called ____body cavities____ that house and protect the major internal organs.

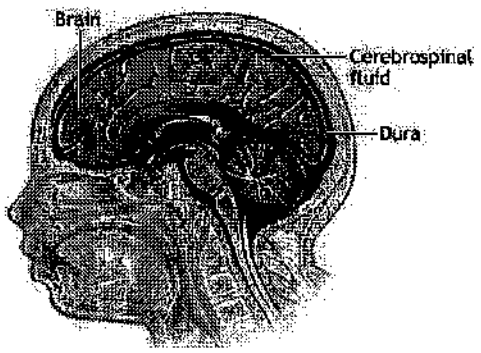
The third collision

11:30 The first collision is between the car and the ___wall___. The second is between the driver and the ____car's interior____. And the third is between the driver's ____internal organs____ and the inside walls of his or her ____body cavities____.

What do you think will happen to the brain during impact?
Circle one: Will it *move forward*, *move backward*, or *stay in the same spot*?

The initial movement of the gel or brain is toward the __back__ of the skull.

This type of brain injury is called coup-contrecoup, which is a French term meaning _____blow-against-blow_____.



Stretch, twist, and tear

13:00 With the heart and its blood vessels, the ascending aorta and its arch are ____mobile____ while the descending aorta is ___fixed___.

Predict what will happen to the unsupported section of gel during the collision:

14:10 The unsupported section of gel ____continues forward____ and tears away from the supported gel.

Stress and strain

14:30 ____Stress____ is a measure of the average deforming force exerted over a defined area of tissue. Stress produces ____strain____. Strain is a measure of how much the tissue ____deforms____ as a result of the stress.

Three basic types of stress are ____tensile____ stress from stretching, ____shearing____ stress from opposing forces, and ____compressive____ stress from uniform compression.

____Trauma____ to human tissue is like failure to a structure.

Shockwaves

16:00 Shockwaves change ____speed____ and/or ____direction____ as they move through tissues of different densities producing complex wave interactions and stress on your organs.

Cell damage and death

Chemicals leaving the cell (circle three): *potassium*, *glutamine*, *phosphate*, *glucose*, *calcium*

Chemicals entering the cell (circle one): *glucose*, *calcium*, *potassium*

This failed auto-regulation can cause areas of the brain to become **ischemic**, that means inadequate ____oxygen____ delivery, and therefore are at risk of malfunction to the point of cellular death.

Building safer race cars

18:00 Crash recorders measure ____accelerations____ in three directions.

Crash recorder data are used to design ____computer models____ that re-enact the crash and help produce design changes.

List three race car safety features brought about by the study of injury biomechanics:

1. ____six-point safety harnesses____
2. ____rigid safety cages or "tubs"____
3. ____energy absorbing "head surrounds"____

breakaway parts and energy absorbing walls are also acceptable answers

19:15

Crash testing at the Vehicle Research Center (VRC)

You try to design the structure of the car so that it crushes in front so you're bringing the car to a stop _____slowly over time_____.

21:06

Bed of nails

Pressure is equal to the ____force____ exerted on a surface divided by the total ____area____ over which the force is exerted.

Pressure = _____F/A_____

More nails means ____less____ pressure.

22:18

Sundown

Keeping people safe in crashes has to do with extending _____impact time_____, keeping the occupant compartment _____intact_____, and _____tying_____ the occupants to the compartment.