

The Structure of DNA

**James D. Watson (1928–) and
Francis Crick (1916–2004)**

Topic

Deoxyribonucleic acid (DNA), the molecule of heredity, is made of two strands of *nucleotides* arranged in a double helix.

Introduction

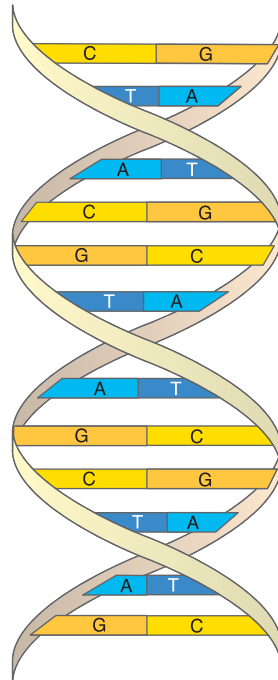
Of all the scientific knowledge gained in the 20th century, the understanding of DNA is perhaps the most remarkable. During the late 1940s and early 1950s, scientists in research labs on both sides of the Atlantic were locked in a race to discover the structure for the molecule of heredity. The winners of this race were two young and relatively unknown scientists, James D. Watson and Francis Crick. Using data from research, Watson and Crick stunned the world with their simple model of the molecule of life (see Figure 1). Their work, which was published in the British journal *Nature* in April of 1953, opened the doors to the science of genetics. In this activity, you will investigate the structure of DNA and construct a model of the molecule.



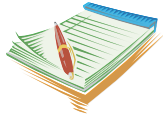
Time Required

50 minutes on day 1

50 minutes on day 2



DNA molecule

Figure 1

Materials

- access to the Internet or biology books on DNA structure
- heavy blue construction paper
- heavy green construction paper
- heavy pink construction paper
- heavy yellow construction paper
- pipe cleaners
- toothpicks
- tape
- ruler
- 10-millimeter (mm) Styrofoam™ balls
- 5-mm Styrofoam™ balls

- large ring stand with ring clamp attached (to be used as a holder for constructing and hanging your DNA molecule)
- scissors
- science notebook

Safety Note Please review and follow the safety guidelines.

Procedure: Day 1

1. Access the Internet or use biology books to research the structure of DNA.
2. In your science notebook, make notes about the structure of DNA. Your notes should include the information needed to answer the questions in the Analysis section of this experiment.

Procedure: Day 2

1. In your science notebook, outline a plan for constructing a model of a section of a DNA molecule.
2. Get your teacher's approval for your DNA construction design.
3. Using the material identified in your outline, construct a model of DNA.

Analysis

1. What are monomers?
2. What are the monomers that make up DNA?
3. What is a nucleotide of DNA made of?
4. What type of chemical bond holds the DNA backbone together?
5. How many strands are required to make a molecule of DNA?
6. What is the molecular shape of DNA?

7. What are the four nitrogen bases used in DNA?
8. How do the nitrogen bases in DNA pair up?
9. What are purines? Provide two examples.
10. What are pyrimidines? Provide two examples.



What's Going On?

The basic structure of DNA is described as “universal” because it is the same in all living things. A DNA molecule is made of two strands of nucleic acids that are held together by hydrogen bonds. Backbones of alternating sugars and phosphate groups act as supports for each strand of nucleotides. The entire structure is twisted into a double helix. Watson and Crick’s discovery of the structure of DNA led to the description of human DNA through the Human Genome Project. From this research, scientists have discovered the causes, and possible cures, of many genetic diseases.

Want to Know More?

See Our Findings.

OUR FINDINGS

THE STRUCTURE OF DNA

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Suggestion for class discussion: Ask students if they are familiar with the concept of DNA fingerprinting. How is it used in forensic science? Extend this discussion to include the structure of DNA and the techniques of analyzing it.

Teacher notes: One great DNA website is http://www.blc.arizona.edu/Molecular_Graphics/DNA_Structure/DNA_Tutorial.HTML

Analysis

1. Monomers are structural molecules that are used repeatedly to construct a polymer chain.
2. Monomers of DNA are nucleotides.
3. A DNA nucleotide is made of a 5-carbon sugar called deoxyribose, a nitrogen base, and a phosphate group.
4. Phosphodiester bonds.
5. Two strands of nucleotides are required.
6. It is shaped into a double helix.
7. Adenine, thymine, cytosine and guanine.
8. Adenine always pairs with thymine; cytosine always pairs with guanine.
9. Purines are larger, double-ringed nitrogen bases. Two examples would be adenine and guanine.
10. Pyrimidines are smaller, single-ringed nitrogen bases. Two examples would be thymine and cytosine.

SAFETY PRECAUTIONS

Review Before Starting Any Experiment

Each experiment includes special safety precautions that are relevant to that particular project. These do not include all the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read and remain mindful of the General Safety Precautions that follow this note. Experimental science can be dangerous, and good laboratory procedure always includes following basic safety rules. Things can happen very quickly while you are performing an experiment. Materials can spill, break, or even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following the basic safety guidelines during the entire experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. For one reason, we want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical.

Read the safety precautions here and at the beginning of each experiment before performing each lab activity. It is difficult to remember a long set of general rules. By rereading these general precautions every time you set up an experiment, you will be reminding yourself that lab safety is critically important. In addition, use your good judgment and pay close attention when performing potentially dangerous procedures. Just because the book does not say “Be careful with hot liquids” or “Don’t cut yourself with a knife” does not mean that you can be careless when boiling water or using knives. Notes in the text are special precautions to which you must pay special attention.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking an unnecessary risk can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the individual experiments in this book for additional safety regulations and adult supervision requirements. Anytime you are working with an electrical current, it becomes possible to shock yourself on exposed wires. If you will be working in a lab, do not work alone. When

you are working off-site, keep in groups with a minimum of three students per group, and follow school rules and state legal requirements for the number of supervisors required. Ask an adult supervisor with basic training in first aid to carry a small first-aid kit. Make sure everyone knows where this person will be during the experiment.

PREPARING

- Clear all surfaces before beginning experiments.
- Read the instructions before you start.
- Know the hazards of the experiments and anticipate dangers.

PROTECTING YOURSELF

- Follow the directions step by step.
- Do only one experiment at a time.
- Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eyewash, and first-aid kit.
- Make sure there is adequate ventilation.
- Do not horseplay.
- Keep floor and workspace neat, clean, and dry.
- Clean up spills immediately.
- If glassware breaks, do not clean it up by yourself; ask for teacher assistance.
- Tie back long hair.
- Never eat, drink, or smoke in the laboratory or workspace.
- Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult.

USING EQUIPMENT WITH CARE

- Set up apparatus far from the edge of the desk.
- Use knives or other sharp, pointed instruments with care.
- Pull plugs, not cards, when removing electrical plugs.
- Clean glassware before and after use.
- Check glassware for scratches, cracks, and sharp edges.
- Let your teacher know about broken glassware immediately.
- Do not use reflected sunlight to illuminate your microscope.
- Do not touch metal conductors.
- Use alcohol-filled thermometers, not mercury-filled thermometers.

USING CHEMICALS

- Never taste or inhale chemicals
- Label all bottles and apparatus containing chemicals
- Read labels carefully.
- Avoid chemical contact with skin and eyes (wear safety glasses, lab apron, and gloves).
- Do not touch chemical solutions.
- Wash hands before and after using solutions.
- Wipe up spills thoroughly.

HEATING SUBSTANCES

- Wear safety glasses, apron, and gloves when boiling water.
- Keep your face away from test tubes and beakers.
- Use test tubes, beakers, and other glassware made of Pyrex™ glass.
- Never leave apparatus unattended.
- Use safety tongs and heat-resistant gloves.
- If your laboratory does not have heat-proof workbenches, put your Bunsen burner on a heat-proof mat before lighting it.
- Take care when lighting your Bunsen burner; light it with the airhole closed, and use a Bunsen burner lighter rather than wooden matches.
- Turn off hot plates, Bunsen burners, and gas when you are done.
- Keep flammable substances away from flames and other sources of heat.
- Have a fire extinguisher on hand.

FINISHING UP

- Thoroughly clean your work area and any glassware used.
- Wash your hands.
- Be careful not to return chemicals or contaminated reagents to the wrong containers.
- Do not dispose of materials in the sink unless instructed to do so.
- Clean up all residues and put in proper containers for disposal.
- Dispose of all chemicals according to all local, state, and federal laws.

BE SAFETY CONSCIOUS AT ALL TIMES!