copper

in the Environment

Vital

Natural

Essential

Sustainable

Universal

copper in the Environment

INTRODUCTION

Copper is a natural element – a metal that has been one of mankind's most useful and valuable materials since time immemorial. It is represented by the chemical symbol Cu and the atomic number 29.

Copper is also an essential nutrient that is required by virtually all higher life forms. A natural element in the earth's crust, copper has been incorporated into living organisms throughout the evolutionary process. Without copper, life as we know it would be impossible for most of earth's organisms.

Nature, in its myriad forms, is exceedingly well adapted to making best use of copper and protecting itself from any negative effects. This holds true at the most basic level of chemical reactions, right up to the most complex metabolic functions of the human body.

THIS BOOKLET DISCUSSES SOME OF THE MOST IMPORTANT WAYS THAT COPPER INTERACTS WITH THE ENVIRONMENT AND, IN PARTICULAR, WITH THE HUMAN BODY.

Nature regulates the uptake and excretion of copper in an almost perfect way. Copper is not magnified in the body nor bioaccumulated in the food chain.

From prehistory to the present day, humanity has put copper to use to advance civilization. In present times, for example, electric technologies – and all that these advancements mean to safe, efficient modern-day living – would be impractical, if not impossible, were it not for copper's extraordinary properties of electrical conductivity.

Copper contributes to our well-being every day. In a wide range of technological advancements – in fields ranging from medical equipment to energy efficiency, from jet planes to satellites, from radio and television to the Internet – copper has shown itself to be a metal for the future.

While technological progress has brought countless benefits, mankind has grown increasingly concerned about the impacts of technology and industry on the natural environment and human health and well-being. Since it is one of the most important materials in construction and technology, as well as an essential nutrient required for human health, the impact of copper on the environment is an area of continuing scientific and academic interest.

As knowledge and understanding of these impacts grow, scientists are discovering that copper interacts with the environment in extremely complex ways. Fortunately, copper's overall contribution is overwhelmingly beneficial – indeed, we would face serious problems without it.

COPPER'S BENEFITS TO MANKIND ARE VARIED AND VALUABLE. CONSIDER THESE FEW EXAMPLES:

PROMOTES PURITY

Copper plumbing promotes water purity and cleanliness. Copper tube is the material of choice in plumbing and for supplying potable water. In addition to its durability, copper acts as an effective anti-pathogen, killing or inhibiting growth of bacteria, viruses, parasites, fungus and other health-threatening, water-borne organisms. Copper tube is also non-porous, protecting drinking water from contaminants such as petrochemicals and insecticides.

ESSENTIAL NUTRIENT

Copper is a micro-nutrient that is essential for human health. Human nutritional requirements demand a small but regular intake of dietary copper in order to maintain health and keep the body functioning properly. Copper is particularly important for infant growth, as well as for the operation of a number of the body's key systems.

ENERGY-EFFICIENT

Copper wiring is energy-efficient.

Due to its exceptional conductivity, ease of use and corrosion-resistance, copper is one of the world's most reliable and efficient mediums for transporting electric power. Copper wiring allows the least possible amount of power to be lost in transmission, conserving energy and reducing demand on generating capacity. Copper wire combines high conductivity with ease of use.

ADDS BEAUTY

Copper has great aesthetic appeal.

Copper's combination of durability, ductility and luster has long made it a preferred material of artisans, craftsmen and builders who seek to invest their creations with lasting beauty. As a construction material used for roofing or cladding, the graceful effect of copper's aging over the decades has long been a symbol of architectural elegance, longevity and distinction.

RECYCLABLE

Copper is virtually one hundred percent recyclable.

Most copper in use – such as roofing, wiring and plumbing tube – will remain in use for decades or longer. Even so, the large, well-established recycling infrastructure that exists for these and other copper products, together with the high value of recycled materials, has long made copper one of the most widely recycled of all metals.

COPPER IS NEEDED BY ALL HUMAN BEINGS TO MAINTAIN HEALTH. It is an essential component of dietary nutrition that enables the body to metabolize and function properly.

Since copper is an essential micronutrient, it does not present health risks at levels normally ingested from our food and water. Studies have shown that copper in humans is involved in the functioning of human enzymes and is required for infant growth, the transport of iron in the bloodstream, bone strength, the metabolism of glucose and cholesterol, brain development, and heart, liver, nerve and immune system functions.

It is used therapeutically to treat skin disorders and bacterial infection, to counteract cases of phosphorus poisoning, and to combat gout and some cancers.

Copper deficiency in the diet can cause a number of serious health consequences resulting in disease. Far less common, excessive intake of copper can induce short-term gastrointestinal disturbance. In addition, certain rare genetic abnormalities can result in breakdowns of the body's ability to properly utilize copper that, in some circumstances, can be fatal.

Nutritional Requirements

The recommended daily requirement of dietary copper is 1-2 mg. for adults and 0.5-1 mg. for children.* This requirement is met by taking in copper through a balanced diet rich in cereals, meat, root vegetables, legumes, wine, nuts and even chocolate. Drinking water is a minor source of copper, as is atmospheric dust.

Copper is especially essential for pregnant women and the developing fetus, as well as for newborns. In the third trimester, expectant mothers are advised to double their normal intake of dietary copper to ensure the fetus receives all that it needs.

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**United States Department of Agriculture*.

COPPER IS ESPECIALLY ESSENTIAL FOR PREGNANT WOMEN AND THE DEVELOPING FETUS.

Copper is an essential component of dietary nutrition that enables the body to metabolize energy and function properly.

Copper is stored in the fetal liver, where it can reach levels that are ten times greater than typical adult levels. After birth, the baby will need this copper for growth and development, and will excrete any excess that is not required.

Because copper is a natural substance that has always been with us in our bodies and environment, the human body has evolved an extremely effective and well-developed internal homeostatic, or regulatory mechanism to ensure the copper we take in is put to use and any excess is harmlessly eliminated.

As a result of this mechanism, between 25 and 60 percent of the copper taken up by the body is absorbed for use, and the balance is excreted in bile, urine or perspiration.

Diseases

Three serious diseases – each one genetic in origin – are associated with improper utilization of bodily copper. These diseases are hereditary and genetically predetermined; therefore, controlled copper levels in diet or drinking water will provide no relief from these diseases. They are:

- *Wilson's disease*, which causes an excess of copper to build up in the liver, and which can be managed through therapy;
- *Menke's disease*, an X-linked, fatal disorder that causes a failure in the liver's ability to absorb copper, leading to copper deficiency, and
- *Idiopathic Copper Toxicosis (ICT)*, an extremely rare childhood disease – once found in remote, rural communities, and now only in isolated, rare cases – that leads to a build-up of copper in the liver, causing cirrhosis, which can be fatal.

Genetic research aimed at identifying and screening for the genes associated with these illnesses is a matter of intensive, ongoing scientific activity.

Copper Protects Drinking Water

There are significant health and safety benefits to copper-tube plumbing, including copper's proven role as an anti-pathogen effective at eliminating a variety of infectious parasites, algae and opportunistic bacteria and viruses – including forms of *Legionella*, and polio.

These effects on pathogens have been documented even when the copper level in the water is below guideline levels for potable water. In addition, Copper pipes are non-porous, preventing contaminants such as petrochemicals, insecticides, or organic materials from polluting the water supply.

Copper is a natural, environmentally friendly material that has been used to deliver drinking water since the time of the pharaohs. Copper plumbing does not contribute to the waste cycle, since copper pipes last for decades and, when no longer needed, are completely recyclable.

COPPER IS A NATURAL, ENVIRONMENTALLY FRIENDLY MATERIAL THAT HAS BEEN USED TO DELIVER DRINKING WATER SINCE THE TIME OF THE PHARAOHS.

Water passing through copper plumbing tube does pick up minute amounts of copper. The relative amount depends upon the chemistry of the incoming water. Water with a low pH (high acidity) will pick up relatively more copper. More copper tends to be picked up from newly installed plumbing tube, but, as a protective layer of oxide and carbonate quickly forms as the tube ages, the amount of copper in the water is reduced. This usually happens within a few months of installation.

There is no evidence of chronic health problems due to copper in potable water, and the occurrence of any short-term symptoms such as stomach upset, nausea, diarrhea, and, in severe cases, vomiting, are exceedingly rare.

Usually, copper build-up in drinking water can be eliminated simply by running the tap long enough to move through the pipes all the water that has been sitting stagnant overnight or for a long period of time.

COPPER IS NATURALLY PRESENT IN ALL WATER AND AQUATIC ENVIRONMENTS, including sediments. Not surprisingly, therefore, it also turns up in water for human use – including potable water supplies (discussed in the prior section) and wastewater discharges.

There is a well-established approach to deciding how much of an element or chemical (such as copper) can be present in a body of water before there is a risk to the environment. This process, called "risk assessment," has been formalized as the basis for environmental regulations around the world.

The critical dimension of copper's effects in water is determined by what is referred to as "bio-availability," defined as the degree to which the substance is available to be taken up and absorbed or used in a physiological activity or system of a plant, animal or human. Since copper is a naturally occurring element and is an essential nutrient and can be metabolized, its bio-availability is not measured in the same way as man-made chemicals are measured.

Typically, the bio-availability of copper present in water is many times less than the total concentration.

In determining bio-availability, much depends on whether the copper found in the water is in a particulate or dissolved state. The bio-availability is also determined by the pH level and hardness of the water and the metabolic characteristics of the particular organism interacting with the copper. Many waterborne agents like silt, sediments and other metals react with copper to "lock it up," thus reducing its bio-availability. Naturally occurring copper compounds tend to "sponge-up" most of the copper in the water.

Most organisms are well adapted to copper and actually require its presence to function properly. However, in circumstances where the free copper ion is present in sufficient levels, it can negatively affect sensitive aquatic species. Like humans, aquatic organisms usually have the self-regulating mechanisms that ensure their systems get the copper they need, while enabling them to shed any excess without harm.

These and other factors create an extremely complex web of interactions not given to broad generalization about the effects of copper in water. Localized conditions will always be the key determinant.

Sewage, sludge and discharged water

Copper enters public sewerage systems from three main sources in many countries: (1) industrial and commercial wastewater, contributing up to 40 percent of the total; (2) stormwater and surface runoff, between 30-35 percent of total amounts; and (3) domestic wastewater – including human waste – representing the balance.

Sewage treatment is a highly effective method of separating copper (and other metals) from water and binding it to the sludge. About 80 percent of copper in wastewater is captured this way in treatment.

Of the smaller share that is discharged into waterways, most is not bio-available and settles harmlessly in sediments, or is immobilized by binding with organic compounds in the environment. Only rarely is copper present in waterways in a bio-available form that could affect water quality or aquatic life.

Similarly in sewage sludge, copper is most commonly found in forms that render it immobile and unable to have wider effect. For this reason, copper's presence in sludge does not generally limit the beneficial re-use of that sludge for agricultural or other purposes.

MOST ORGANISMS ARE WELL ADAPTED TO COPPER AND ACTUALLY REQUIRE ITS PRESENCE TO FUNCTION PROPERLY.

Copper is a naturally occurring element.

COPPER IS FOUND IN ALL SOILS THROUGHOUT THE WORLD, but not in uniform quantities. Many soils have insufficient levels of copper, including agricultural land and land for livestock. This is especially problematic for agriculture. As with humans, plant and animal health relies on adequate copper intake.

Copper deficiency is a major issue in global food production, resulting in costly losses in yield and lower-quality output – in both crops and livestock. The world's two most important food crops, rice and wheat, are highly susceptible to copper deficient soil. So are several other important foods, including citrus, oats, spinach and carrots, to name a few. Some foods, including coconuts, soybeans and asparagus, are not particularly sensitive to low-copper soils.

In livestock, cattle and sheep both commonly show indications of copper deficiency. Swayback – a sheep disease associated with copper deficiency – imposes enormous costs on farmers worldwide, particularly in Europe, North America and many tropical countries. For pigs, copper has been shown to be an outstanding growth promoter.

Nitrogen fertilizers have the effect of worsening copper deficiency in agricultural soils. The most effective strategy to counter copper deficiency is by soil amendment, for which sewage sludge with adequate copper present is an excellent method.

AS WITH HUMANS, PLANT AND ANIMAL HEALTH AND NUTRITION RELY ON ADEQUATE COPPER INTAKE.

The world's two most important food crops - rice and wheat - are both highly dependent on sufficient copper in soil.

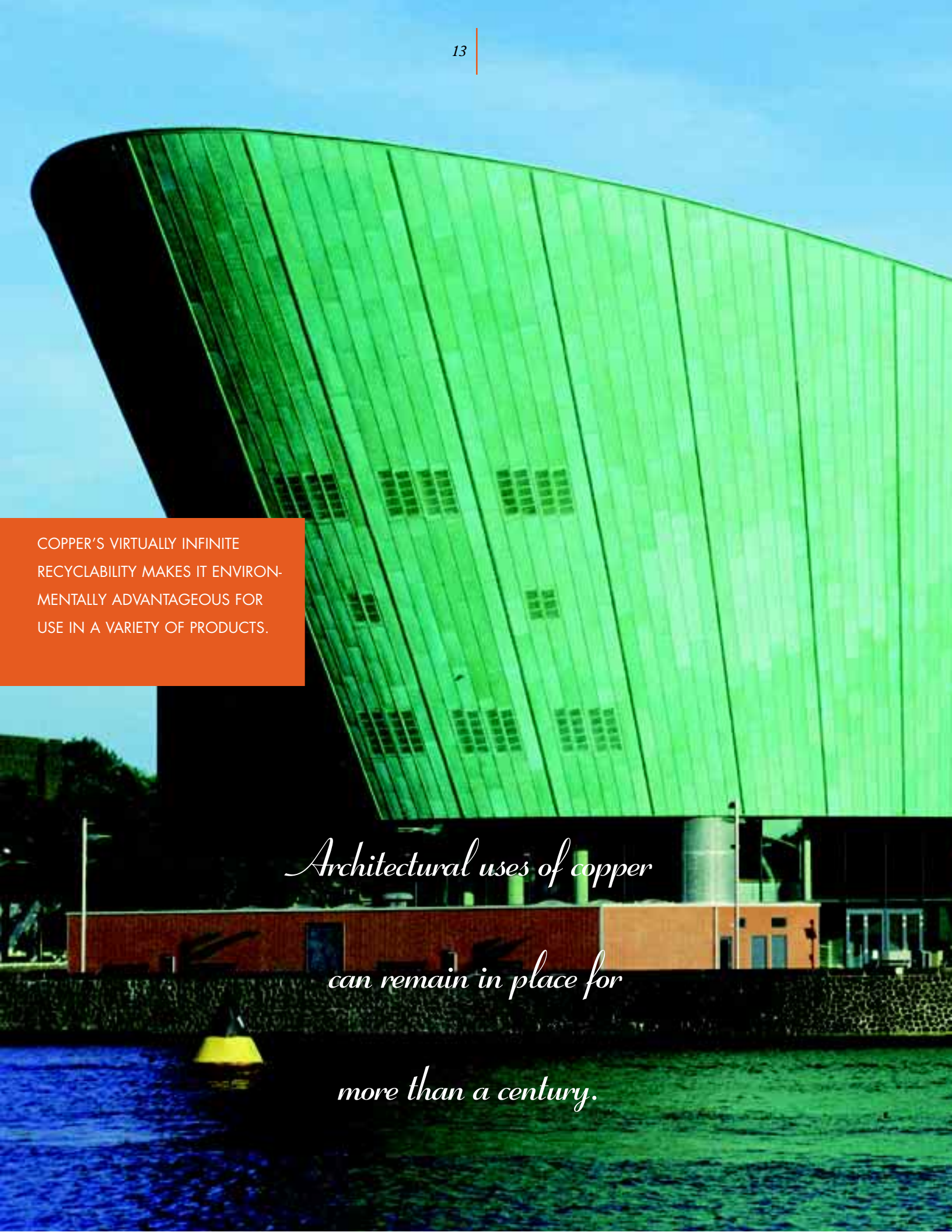
FOR AS LONG AS HUMANS HAVE PUT COPPER TO USE – about 10,000 years – they have taken advantage of the fact that it is virtually one hundred percent recyclable. Craftsmen knew that the implements and ornaments they fashioned from copper were highly valued, so it has always been a matter of economic good sense to retrieve as much copper as possible at the end of its life-cycle, and re-use it for some new purpose.

Today, the process is no different. According to recent data (1997) some 38 percent of the 15 million tons of copper used annually worldwide has been recycled from prior uses. This is a significantly higher percentage of reuse than is the case for aluminum, which is often regarded as a benchmark metal for recycling effectiveness.

In fact, the level of copper recycling is even more noteworthy when considered in light of the extremely long life-cycles of copper's principal products: wiring, roofing and plumbing. Electrical cables and wires and waterpipes typically last for decades; architectural uses of copper such as cladding and roofing can remain in place for more than a century at a time.

A major source of secondary copper is from auto radiators, which, by definition, only remain in use as long as the relatively short life span of the vehicles themselves – under a decade. Because of its recyclability, in combination with exceptional energy-to-weight efficiency and thermal conductivity, copper is becoming the material of choice for radiators in environmentally sensitive vehicle design.

Although copper's virtually infinite recyclability makes it environmentally advantageous for use in a variety of products, worldwide demand cannot be met exclusively by secondary copper. Continued production of new copper is also required to meet human needs. Fortunately, ample reserves have been identified to last for many generations.



COPPER'S VIRTUALLY INFINITE RECYCLABILITY MAKES IT ENVIRONMENTALLY ADVANTAGEOUS FOR USE IN A VARIETY OF PRODUCTS.

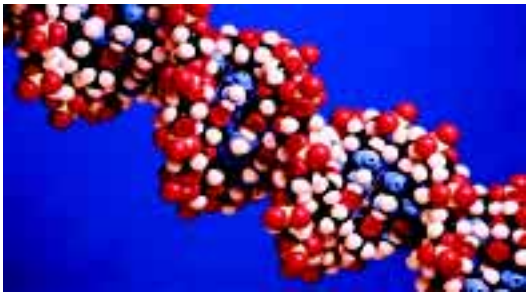
Architectural uses of copper can remain in place for more than a century.

COPPER HAS BEEN THE SUBJECT OF SCIENTIFIC AND TECHNICAL INQUIRY and experimentation throughout the ages. Today, a good deal of that research is focused on copper's role in the environment.

The International Copper Association – the sponsor of this booklet – also underwrites extensive original research to develop a better knowledge base and deeper understanding of copper's environmental behavior and how that affects ecosystems, human health, and plant and animal nutrition.

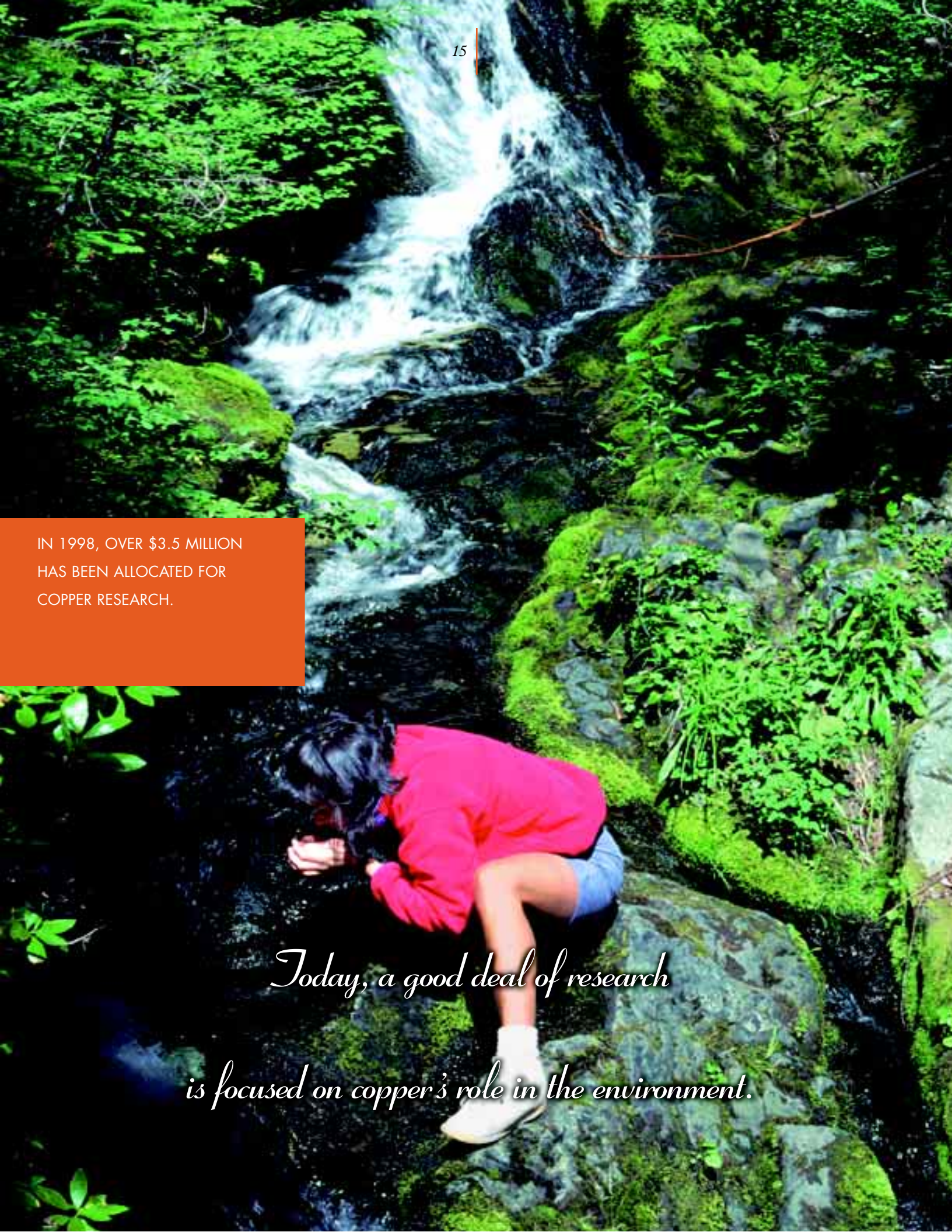
In 1998, over $3.5 million has been allocated for this research, which is conducted worldwide by independent scholars and scientists and subject to peer review.

Among the key areas currently under study are:



- Identification of the specific genes involved in Wilson's disease, Menke's disease and Idiopathic Copper Toxicosis;
- Understanding of the biochemistry of copper deficiency in aquatic species;
- Development of methods to reliably predict the bio-availability of copper under site specific conditions;
- Understanding of the epidemiology of acute copper intake internationally;
- Surveying the various origins of copper in stormwater runoff;
- Quantifying the total net energy usage/savings derived from the retrieval and processing of copper for secondary use.

These and other research projects now under way or planned for the near future, will contribute further to science's understanding of copper's properties, thus helping mankind to make more efficient and environmentally positive use of this vital element.



IN 1998, OVER $3.5 MILLION HAS BEEN ALLOCATED FOR COPPER RESEARCH.

Today, a good deal of research is focused on copper's role in the environment.

THROUGHOUT THE HISTORY OF CIVILIZATION, copper has been indispensable to human progress. All the indicators point toward a future in which copper will continue to be one of the most useful and valuable of all the earth's resources.

As a result, we can look far into the future with the expectation that copper will continue its historic role as a material that helps keep drinking water safe and pure; that conducts electricity reliably and efficiently; that helps maintain good human health; that adds beauty and durability to buildings and countless other products; and that is continuously recovered and recycled after it is used.

As science continues to help us better comprehend the world we live in, we can develop a greater understanding of how to more effectively manage copper's use in order to yield optimum benefits and investigate the role of copper in the environment. This will be the key to ensuring that humanity continues to be well served by this singular, essential metal.

COPPER WILL CONTINUE TO BE ONE OF THE MOST USEFUL AND VALUABLE OF ALL THE EARTH'S RESOURCES.

COPPER

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