AUGUST 2014

FOOD HUNGER IN AMERICA | JANE GOODALL AT 80

NATIONAL GEOGRAPHIC

THE FIRST STONEHENGE

Scotland's Master Builders



The Stones of Stenness were built on the Orkney Islands some 5,000 years ago.



African Lion *(Panthera leo)*
Size: Head and body length, 170 - 250 cm (66.9 - 98.4 inches) ; tail, 70 - 105 cm (27.6 - 41.3 inches) **Weight:** 120 - 250 kg (264 - 551 lbs) **Habitat:** Grassy plains, savannahs, open woodlands and scrub country **Surviving number:** Estimated at 32,000

Photographed by Michael Nichols

WILDLIFE AS CANON SEES IT

All hail the king. A magnificent hunter, the African lion is capable of leaping some 40 feet and running over 35 miles per hour when closing with prey. Often hunting in groups, these huge felines generally strike at night but are also active during the day. Prides consist of related females and their young, along with a male or coalition of males. The larger the pride, the higher quality hunting grounds it can command. But the depletion of prey, trophy hunting and retaliation for livestock depredation all threaten to end their royal reign.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.



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VOL. 226 • NO. 2

NATIONAL GEOGRAPHIC

The sun doesn't set; it just loops around irresolutely in the northern sky.
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Technology could keep swimmers and surfers safe.

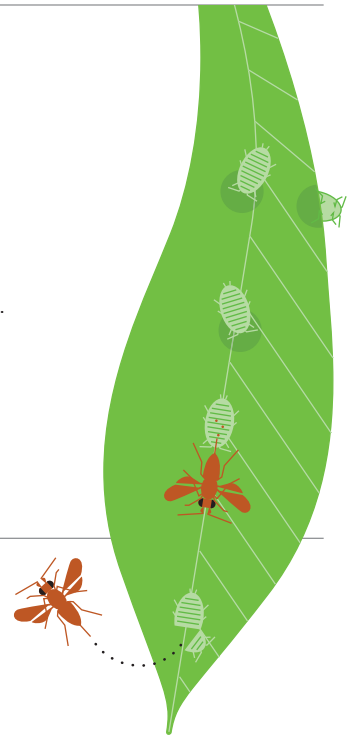
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The Moment
Found

On the Cover The Stones of Stenness—a Neolithic ceremonial circle older than Stonehenge—stand watch on the Scottish archipelago of Orkney. *Photograph by Jim Richardson*

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Orkney Islands
Video
Explore the archaeology of the archipelago.



Hunger in America
Video
Reaching out in rural Arkansas



World War I
Gallery
See life in the trenches.

PHOTO: SHANNON SANDERS, NGM STAFF (HUNGER)

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"The New Face of Hunger" in this issue is part of our special series on food. See more online at **natgeofood.com** and on Twitter at **#FutureofFood.**

Hunger in America

I'll never forget the words of the Cleveland school administrator or how awful I felt when he uttered them. It was 2007, and, as the new editor of the *Plain Dealer,* the city's daily newspaper, I was meeting with a group involved in improving public education. The topic turned to Cleveland's "lake effect," which dumps about 68 inches of snow on the city each year.

"The kids must love all the snow days," I joked.

The room went silent. People exchanged glances.



"We try never to close the schools," one man finally said. "When we do, a lot of kids won't eat."

I'm embarrassed to admit this had never occurred to me before.

Hunger in America today doesn't look like the Dorothea Lange photos of hollow-eyed unemployed people during the Depression, but it is hunger even so. These days the hungry are often "white, married, clothed, and housed, even a bit overweight," writes Tracie McMillan in this month's story "The New Face of Hunger."

One in six Americans says food runs out at least once a year, compared with one in 20 in many European countries. Emergency food programs have ballooned from a few hundred in 1980 to 50,000 today. At the same time schools quietly have become de facto food banks for astonishing numbers of children.

Last year about 19 million students received a free school lunch; another 2.5 million got a reduction in the price. On Fridays districts from Oklahoma City to Rochester, New York, help hand out food to tide kids over until Monday. In summer, cities like Washington, D.C., have created programs to fill the meal gap.

But no one has a good solution for unexpected snow days. Last year, depending on location, Cleveland schools closed for eight or nine days. That's a lot of kids who didn't get fed.

"There is a hidden crisis," says Eric Gordon, chief executive officer for the Cleveland Metropolitan School District, where 45,000 free meals are served daily to students from kindergarten through 12th grade. "If you take us out of the picture, there are a lot of kids who won't eat."

Our society, Gordon says, has chosen to ignore this reality. He can't.

Neither should we.

Thank you for reading,



Susan Goldberg, *Editor in Chief*

PHOTO: KELLY CLINE, GETTY IMAGES



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Wild Obsession

To the folks who have so much passion for animals: Put your efforts into good programs to protect natural habitat, stop the illegal trade in animal parts, and support accredited sanctuaries. Listen to the former exotic-pet owners who realized that the best thing they could do for their beloved animals was to find a proper sanctuary. It's difficult to hear the tragic stories of accidents that happen. Far too often it is the animal that pays the ultimate price of these accidents with its life or worse, isolation, because it was "bad." There is nothing right about that at all.

VALERIE SMITH
San Diego, California

In the early 1970s I visited a local pet store in southern California and on the spur of the moment decided to order a lesser anteater. A few months later an eight-week-old baby anteater arrived. She was charming and used her long, wispy tongue to search through my hair for bugs and spent most of her time lounging on curtain rods in our home. Her diet was complicated, and I didn't have the time to care for her, and I returned her to the pet store. Years later I realized that the only way this delightful creature arrived at my home was for someone in another country to have tracked down and killed her mother, prying her from her mother's lifeless body, so she could be shipped to the U.S. I have never forgiven myself for this thoughtless act, and I hope that the U.S. continues to do everything possible to prevent such tragedies.

NANCY J. GOTTES
Redding, California

No creature should be held prisoner because of the personal needs of people. Taking an animal out of its natural environment is analogous to killing its spirit. There is no justification for the heinous act of capturing wild creatures to satisfy our lust for power or our need to overcome loneliness. All beings are miracles of nature. We should dismantle all zoos. The only excuse for holding a wild animal captive is to rehabilitate it or give it a permanent shelter because it cannot survive in the wild.

NEAL GRACE
San Rafael, California

Corrections

APRIL 2014, COSMIC DAWN On the gatefold graphic the labels for hydrogen and helium atoms should be switched. Also, in the "first nuclei" stage the helium and hydrogen nuclei should be composed only of protons and neutrons.

NEXT: COMMUTER SCIENCE The study represented here showed extra time spent in traffic during 2012.

FEEDBACK *Readers shared their views on ownership of exotic animals.*



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WRITE National Geographic Magazine, PO Box 98199, Washington, DC 20090-8199. Letters may be edited for clarity and length.

ART: EMILY M. ENG



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VISIONS



Emirate of Abu Dhabi
As the sun sets on the Liwa region, local tribesmen lead their camels to a grazing area in neighboring Saudi Arabia. These shifting sands create huge crescent-shaped dunes, which move slowly and can reach 500 feet high.

PHOTO: KARIM SAHIB, AFP/GETTY IMAGES





England
In the village of Box, George Purser, 77, waters geraniums on a century-old traction engine. He bought the self-propelled steam engine 33 years ago for $100. Before it became a flower bed, it was used to thresh corn and sterilize topsoil.

PHOTO: CHARLIE HAMILTON JAMES





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Cyprus
When Mediterranean mantises are startled, they wave their forelimbs and raise their wings to reveal vivid eyespot markings. These two adult females, each less than three inches long, were spotted in an alfalfa field near Nicosia.

PHOTO: HASAN BAĞLAR

For people with a higher risk of stroke due to
Atrial Fibrillation (AFib) not caused by a heart valve problem



ELIQUIS® (apixaban) is a prescription medicine used to reduce the risk of stroke and blood clots in people who have atrial fibrillation, a type of irregular heartbeat, not caused by a heart valve problem.

IMPORTANT SAFETY INFORMATION:

- **Do not stop taking ELIQUIS for atrial fibrillation without talking to the doctor who prescribed it for you. Stopping ELIQUIS increases your risk of having a stroke.** ELIQUIS may need to be stopped, prior to surgery or a medical or dental procedure. Your doctor will tell you when you should stop taking ELIQUIS and when you may start taking it again. If you have to stop taking ELIQUIS, your doctor may prescribe another medicine to help prevent a blood clot from forming.
- **ELIQUIS can cause bleeding, which can be serious,** and rarely may lead to death.
- **You may have a higher risk of bleeding if you take ELIQUIS and** take other medicines that increase your risk of bleeding, such as aspirin, NSAIDs, warfarin (COUMADIN®), heparin, SSRIs or SNRIs, and other blood thinners. **Tell your doctor about all medicines, vitamins and supplements you take.** While taking ELIQUIS, you may bruise more easily and it may take longer than usual for any bleeding to stop.
- Get medical help right away if you have any of these signs or symptoms of bleeding:
  - unexpected bleeding, or bleeding that lasts a long time, such as unusual bleeding from the gums; nosebleeds that happen often, or menstrual or vaginal bleeding that is heavier than normal
  - bleeding that is severe or you cannot control
  - red, pink, or brown urine; red or black stools (looks like tar)
  - coughing up or vomiting blood or vomit that looks like coffee grounds
  - unexpected pain, swelling, or joint pain; headaches, feeling dizzy or weak
- **ELIQUIS is not for patients with artificial heart valves.**
- **Spinal or epidural blood clots or bleeding (hematoma).** People who take ELIQUIS, and have medicine injected into their spinal and epidural area, or have a spinal puncture have a risk of forming a blood clot that can cause long-term or permanent loss of the ability to move (paralysis).

I focused on finding something better than warfarin.

NOW I TAKE ELIQUIS® (apixaban) FOR 3 GOOD REASONS:

1. ELIQUIS reduced the risk of stroke better than warfarin.
2. ELIQUIS had less major bleeding than warfarin.
3. Unlike warfarin, there's no routine blood testing.

ELIQUIS and other blood thinners increase the risk of bleeding which can be serious, and rarely may lead to death.

Ask your doctor if ELIQUIS is right for you.

This risk is higher if, an epidural catheter is placed in your back to give you certain medicine, you take NSAIDs or blood thinners, you have a history of difficult or repeated epidural or spinal punctures. Tell your doctor right away if you have tingling, numbness, or muscle weakness, especially in your legs and feet.

- **Before you take ELIQUIS,** tell your doctor if you have: kidney or liver problems, any other medical condition, or ever had bleeding problems. Tell your doctor if you are pregnant or breastfeeding, or plan to become pregnant or breastfeed.

- **Do not take ELIQUIS if you** currently have certain types of abnormal bleeding or have had a serious allergic reaction to ELIQUIS. A reaction to ELIQUIS can cause hives, rash, itching, and possibly trouble breathing. Get medical help right away if you have sudden chest pain or chest tightness, have sudden swelling of your face or tongue, have trouble breathing, wheezing, or feeling dizzy or faint.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Please see additional Important Product Information on the adjacent page.

Individual results may vary.

Visit ELIQUIS.COM
or call 1-855-ELIQUIS



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Eliquis®
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IMPORTANT FACTS about ELIQUIS® (apixaban) tablets

℞ ONLY

The information below does not take the place of talking with your healthcare professional. Only your healthcare professional knows the specifics of your condition and how ELIQUIS may fit into your overall therapy. Talk to your healthcare professional if you have any questions about ELIQUIS (pronounced ELL eh kwiss).

What is the most important information I should know about ELIQUIS (apixaban)?

For people taking ELIQUIS for atrial fibrillation: Do not stop taking ELIQUIS without talking to the doctor who prescribed it for you. Stopping ELIQUIS increases your risk of having a stroke. ELIQUIS may need to be stopped, prior to surgery or a medical or dental procedure. Your doctor will tell you when you should stop taking ELIQUIS and when you may start taking it again. If you have to stop taking ELIQUIS, your doctor may prescribe another medicine to help prevent a blood clot from forming.

ELIQUIS can cause bleeding which can be serious, and rarely may lead to death. This is because ELIQUIS is a blood thinner medicine that reduces blood clotting.

You may have a higher risk of bleeding if you take ELIQUIS and take other medicines that increase your risk of bleeding, such as aspirin, nonsteroidal anti-inflammatory drugs (called NSAIDs), warfarin (COUMADIN®), heparin, selective serotonin reuptake inhibitors (SSRIs) or serotonin norepinephrine reuptake inhibitors (SNRIs), and other medicines to help prevent or treat blood clots.

Tell your doctor if you take any of these medicines. Ask your doctor or pharmacist if you are not sure if your medicine is one listed above.

While taking ELIQUIS:

- you may bruise more easily
- it may take longer than usual for any bleeding to stop

Call your doctor or get medical help right away if you have any of these signs or symptoms of bleeding when taking ELIQUIS:

- unexpected bleeding, or bleeding that lasts a long time, such as:
  - unusual bleeding from the gums
  - nosebleeds that happen often
  - menstrual bleeding or vaginal bleeding that is heavier than normal
- bleeding that is severe or you cannot control
- red, pink, or brown urine
- red or black stools (looks like tar)
- cough up blood or blood clots
- vomit blood or your vomit looks like coffee grounds
- unexpected pain, swelling, or joint pain
- headaches, feeling dizzy or weak

ELIQUIS (apixaban) is not for patients with artificial heart valves.

Spinal or epidural blood clots or bleeding (hematoma). People who take a blood thinner medicine (anticoagulant) like ELIQUIS, and have medicine injected into their spinal and epidural area, or have a spinal puncture have a risk of forming a blood clot that can cause long-term or permanent loss of the ability to move (paralysis). Your risk of developing a spinal or epidural blood clot is higher if:

- a thin tube called an epidural catheter is placed in your back to give you certain medicine
- you take NSAIDs or a medicine to prevent blood from clotting
- you have a history of difficult or repeated epidural or spinal punctures
- you have a history of problems with your spine or have had surgery on your spine

If you take ELIQUIS and receive spinal anesthesia or have a spinal puncture, your doctor should watch you closely for symptoms of spinal or epidural blood clots or bleeding. Tell your doctor right away if you have tingling, numbness, or muscle weakness, especially in your legs and feet.

What is ELIQUIS?

ELIQUIS is a prescription medicine used to:

- reduce the risk of stroke and blood clots in people who have atrial fibrillation.

(Continued)

- reduce the risk of forming a blood clot in the legs and lungs of people who have just had hip or knee replacement surgery.

It is not known if ELIQUIS is safe and effective in children.

Who should not take ELIQUIS (apixaban)?

Do not take ELIQUIS if you:

- currently have certain types of abnormal bleeding
- have had a serious allergic reaction to ELIQUIS. Ask your doctor if you are not sure

What should I tell my doctor before taking ELIQUIS?

Before you take ELIQUIS, tell your doctor if you:

- have kidney or liver problems
- have any other medical condition
- have ever had bleeding problems
- are pregnant or plan to become pregnant. It is not known if ELIQUIS will harm your unborn baby
- are breastfeeding or plan to breastfeed. It is not known if ELIQUIS passes into your breast milk. You and your doctor should decide if you will take ELIQUIS or breastfeed. You should not do both

Tell all of your doctors and dentists that you are taking ELIQUIS. They should talk to the doctor who prescribed ELIQUIS for you, before you have **any** surgery, medical or dental procedure. **Tell your doctor about all the medicines you take, including** prescription and over-the-counter medicines, vitamins, and herbal supplements. Some of your other medicines may affect the way ELIQUIS works. Certain medicines may increase your risk of bleeding or stroke when taken with ELIQUIS.

How should I take ELIQUIS?

Take ELIQUIS exactly as prescribed by your doctor. Take ELIQUIS twice every day with or without food, and do not change your dose or stop taking it unless your doctor tells you to. If you miss a dose of ELIQUIS, take it as soon as you remember, and do not take more than one dose at the same time. **Do not run out of ELIQUIS.**

Refill your prescription before you run out. When leaving the hospital following hip or knee replacement, be sure that you will have ELIQUIS (apixaban) available to avoid missing any doses. **If you are taking ELIQUIS for atrial fibrillation, stopping ELIQUIS may increase your risk of having a stroke.**

What are the possible side effects of ELIQUIS?

- See **"What is the most important information I should know about ELIQUIS?"**
- ELIQUIS can cause a skin rash or severe allergic reaction. Call your doctor or get medical help right away if you have any of the following symptoms:
  - chest pain or tightness
  - swelling of your face or tongue
  - trouble breathing or wheezing
  - feeling dizzy or faint

Tell your doctor if you have any side effect that bothers you or that does not go away.

These are not all of the possible side effects of ELIQUIS. For more information, ask your doctor or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to FDA at 1-800-FDA-1088.

This is a brief summary of the most important information about ELIQUIS. For more information, talk with your doctor or pharmacist, call 1-855-ELIQUIS (1-855-354-7847), or go to www.ELIQUIS.com.

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March 2014

432US14BR00770-03-01

Your Town

This month, we asked to see portraits of cities looking their best. To see more entries and to find future assignments, visit *ngm.com/yourshot/assignments*.





Michael Filippoff
Foster City, California

One rainy night in San Francisco's North Beach neighborhood, wet sidewalks enhanced the neon glow from an Italian eatery. Filippoff set up his tripod just in time to capture perfectly a red car driving by.

Voltaire Siacor
Bacolod City, Philippines

Last fall at the MassKara Festival in the Philippines, Siacor sat with other photographers while dancers in costume performed onstage. To make his photos different, he used a long exposure that made the colors bleed.

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* 2000, Best Actor in a Leading Role, *Gladiator*



Victor Troyanov Sofia, Bulgaria

While walking through Barcelona during a trip, Troyanov saw a street performer on stilts jumping and dancing to music. The performer slipped into an alleyway to take a break. Troyanov followed him, drawn to the contrast of a large man in a small street.

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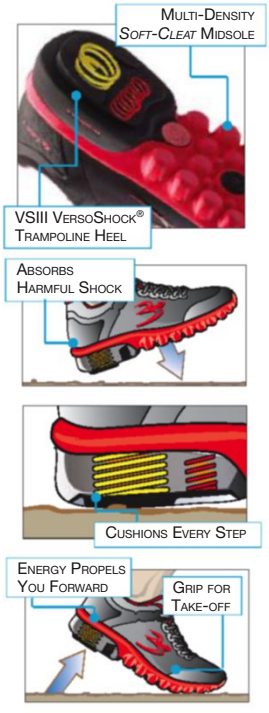
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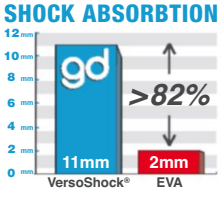
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Ashley Morrison Georgetown, Indiana

Morrison and her mother were "stranded," she says, in Siesta Key, Florida, while a winter storm shut down airports back home. On the beach at dusk, she took candid pictures of people—including one woman in a long red dress—as they made their own photos of the sunset.



Paula Kajzar Reggio di Calabria, Italy

When Kajzar heard about this month's Your Shot assignment, she dug up several old photos that she had taken in Warsaw in 2004. One frame stuck out: eyes from an advertisement reflected in the window of an old hotel.

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NEXGARD kills adult fleas and is indicated for the treatment and prevention of flea infestations *(Ctenocephalides felis)*, and the treatment and control of Black-legged tick *(Ixodes scapularis)*, American Dog tick *(Dermacentor variabilis)*, and Lone Star tick *(Amblyomma americanum)* infestations in dogs and puppies 8 weeks of age and older, weighing 4 pounds of body weight or greater, for one month.

Dosage and Administration:
NEXGARD is given orally once a month, at the minimum dosage of 1.14 mg/lb (2.5 mg/kg).

Dosing Schedule:

Body Weight	Afoxolaner Per Chewable (mg)	Chewables Administered
4.0 to 10.0 lbs.	11.3	One
10.1 to 24.0 lbs.	28.3	One
24.1 to 60.0 lbs.	68	One
60.1 to 121.0 lbs.	136	One
Over 121.0 lbs.	Administer the appropriate combination of chewables	

NEXGARD can be administered with or without food. Care should be taken that the dog consumes the complete dose, and treated animals should be observed for a few minutes to ensure that part of the dose is not lost or refused. If it is suspected that any of the dose has been lost or if vomiting occurs within two hours of administration, redose with another full dose. If a dose is missed, administer NEXGARD and resume a monthly dosing schedule.

Flea Treatment and Prevention:
Treatment with NEXGARD may begin at any time of the year. In areas where fleas are common year-round, monthly treatment with NEXGARD should continue the entire year without interruption.

To minimize the likelihood of flea reinfestation, it is important to treat all animals within a household with an approved flea control product.

Tick Treatment and Control:
Treatment with NEXGARD may begin at any time of the year (see **Effectiveness**).

Contraindications:
There are no known contraindications for the use of NEXGARD.

Warnings:
Not for use in humans. Keep this and all drugs out of the reach of children. In case of accidental ingestion, contact a physician immediately.

Precautions:
The safe use of NEXGARD in breeding, pregnant or lactating dogs has not been evaluated. Use with caution in dogs with a history of seizures (see **Adverse Reactions**).

Adverse Reactions:
In a well-controlled US field study, which included a total of 333 households and 615 treated dogs (415 administered afoxolaner; 200 administered active control), no serious adverse reactions were observed with NEXGARD.

Over the 90-day study period, all observations of potential adverse reactions were recorded. The most frequent reactions reported at an incidence of > 1% within any of the three months of observations are presented in the following table. The most frequently reported adverse reaction was vomiting. The occurrence of vomiting was generally self-limiting and of short duration and tended to decrease with subsequent doses in both groups. Five treated dogs experienced anorexia during the study, and two of those dogs experienced anorexia with the first dose but not subsequent doses.

Table 1: Dogs With Adverse Reactions.

	Treatment Group			
	Afoxolaner		Oral active control	
	N[1]	% (n=415)	N[2]	% (n=200)
Vomiting (with and without blood)	17	4.1	25	12.5
Dry/Flaky Skin	13	3.1	2	1.0
Diarrhea (with and without blood)	13	3.1	7	3.5
Lethargy	7	1.7	4	2.0
Anorexia	5	1.2	9	4.5

[1]Number of dogs in the afoxolaner treatment group with the identified abnormality.
[2]Number of dogs in the control group with the identified abnormality.

In the US field study, one dog with a history of seizures experienced a seizure on the same day after receiving the first dose and on the same day after receiving the second dose of NEXGARD. This dog experienced a third seizure one week after receiving the third dose. The dog remained enrolled and completed the study. Another dog with a history of seizures had a seizure 19 days after the third dose of NEXGARD. The dog remained enrolled and completed the study. A third dog with a history of seizures received NEXGARD and experienced no seizures throughout the study.

To report suspected adverse events, for technical assistance or to obtain a copy of the MSDS, contact Merial at 1-888-637-4251 or www.merial.com/nexgard. For additional information about adverse drug experience reporting for animal drugs, contact FDA at 1-888-FDA-VETS or online at http://www.fda.gov/AnimalVeterinary/SafetyHealth.

Mode of Action:
Afoxolaner is a member of the isoxazoline family, shown to bind at a binding site to inhibit insect and acarine ligand-gated chloride channels, in particular those gated by the neurotransmitter gamma-aminobutyric acid (GABA), thereby blocking pre- and post-synaptic transfer of chloride ions across cell membranes. Prolonged afoxolaner-induced hyperexcitation results in uncontrolled activity of the central nervous system and death of insects and acarines. The selective toxicity of afoxolaner between insects and acarines and mammals may be inferred by the differential sensitivity of the insects and acarines' GABA receptors versus mammalian GABA receptors.

Effectiveness:
In a well-controlled laboratory study, NEXGARD began to kill fleas four hours after initial administration and demonstrated >99% effectiveness at eight hours. In a separate well-controlled laboratory study, NEXGARD demonstrated 100% effectiveness against adult fleas 24 hours post-infestation for 35 days, and was ≥93% effective at 12 hours post-infestation through Day 21, and on Day 35. On Day 28, NEXGARD was 81.1% effective 12 hours post-infestation. Dogs in both the treated and control groups that were infested with fleas on Day -1 generated flea eggs at 12- and 24-hours post-treatment (0-11 eggs and 1-17 eggs in the NEXGARD treated dogs, and 4-90 eggs and 0-118 eggs in the control dogs, at 12- and 24-hours, respectively). At subsequent evaluations post-infestation, fleas from dogs in the treated group were essentially unable to produce any eggs (0-1 eggs) while fleas from dogs in the control group continued to produce eggs (1-141 eggs).

In a 90-day US field study conducted in households with existing flea infestations of varying severity, the effectiveness of NEXGARD against fleas on the Day 30, 60 and 90 visits compared with baseline was 98.0%, 99.7%, and 99.9%, respectively.

Collectively, the data from the three studies (two laboratory and one field) demonstrate that NEXGARD kills fleas before they can lay eggs, thus preventing subsequent flea infestations after the start of treatment of existing flea infestations.

In well-controlled laboratory studies, NEXGARD demonstrated >94% effectiveness against *Dermacentor variabilis* and *Ixodes scapularis*, 48 hours post-infestation, and against *Amblyomma americanum* 72 hours post-infestation, for 30 days.

Animal Safety:
In a margin of safety study, NEXGARD was administered orally to 8- to 9-week-old Beagle puppies at 1, 3, and 5 times the maximum exposure dose (6.3 mg/kg) for three treatments every 28 days, followed by three treatments every 14 days, for a total of six treatments. Dogs in the control group were sham-dosed. There were no clinically-relevant effects related to treatment on physical examination, body weight, food consumption, clinical pathology (hematology, clinical chemistries, or coagulation tests), gross pathology, histopathology or organ weights. Vomiting occurred throughout the study, with a similar incidence in the treated and control groups, including one dog in the 5x group that vomited four hours after treatment.

In a well-controlled field study, NEXGARD was used concomitantly with other medications, such as vaccines, anthelmintics, antibiotics (including topicals), steroids, NSAIDS, anesthetics, and antihistamines. No adverse reactions were observed from the concomitant use of NEXGARD with other medications.

Storage Information:
Store at or below 30°C (86°F) with excursions permitted up to 40°C (104°F).

How Supplied:
NEXGARD is available in four sizes of beef-flavored soft chewables: 11.3, 28.3, 68 or 136 mg afoxolaner. Each chewable size is available in color-coded packages of 1, 3 or 6 beef-flavored chewables.

NADA 141-406, Approved by FDA
Marketed by: Frontline Vet Labs™, a Division of Merial Limited.
Duluth, GA 30096-4640 USA

Made in Brazil.

1050-4493-02
Rev. 4/2014

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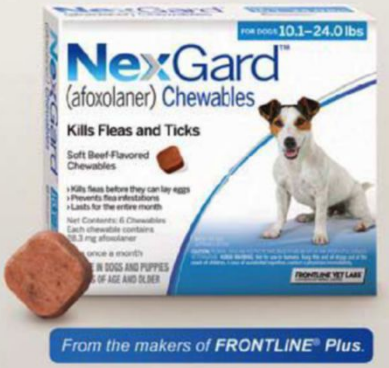
Chew on this fleas & ticks



NexGard™ from the makers of FRONTLINE® Plus. The only soft, beef-flavored chew for dogs that kills both fleas and ticks.

And it keeps killing for a full 30 days. Fleas and ticks hate it. Vets recommend it.[1] And dogs, well, they're begging for it.[2]

For more information, ask your vet or visit NexGardForDogs.com.



IMPORTANT SAFETY INFORMATION

NexGard is for use in dogs only. The most frequently reported adverse reactions include vomiting, dry/flaky skin, diarrhea, lethargy, and lack of appetite. The safe use of NexGard in pregnant, breeding or lactating dogs has not been evaluated. Use with caution in dogs with a history of seizures.

1. Data on file at Merial.
2. Data on file at Merial.

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Now you can listen to your CDs, MP3s, AM/FM radio, Pandora® and other Internet radio all from one system. And with six programmable presets, you can hear your favorite playlists, albums or stations – wherever they are – at the touch of a button. Small enough to fit in any room in your house and powerful enough to fill it with lifelike sound, the Wave® SoundTouch™ connects to your existing home Wi-Fi® network, so no extra equipment is necessary to stream your music. Try it risk-free for 30 days with free shipping. And when you call, ask how you can make easy payments with no interest charges from Bose. Listening to your music has never been simpler – or better. To order, call or visit us online today.

Order now directly from Bose. **1.800.400.3956,** ext. **TZ1331** | **Bose.com/WaveWifi**

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NEXT

SKYCAST

Overhead this month in parts of the world

August 12
Perseid meteor shower

August 29
Neptune closest to Earth



Averting Attack

Some of the newest innovations in beach gear deal with safety, not style. To ward off lurking sharks, wearable deterrent devices that emit a small electrical field have surged in popularity.

The device—worn around the ankle or embedded in a surfboard (above, deactivated after a test)—drives sharks away but does not harm them. Its electrical pulses disturb small sensors in the shark's snout that ordinarily detect the weak electrical field given off by living prey. The technology has been tested against species like blacktip and spinner sharks as well as the more dangerous great white. "Those are the ones we really want to protect against," says biologist George Burgess. Research with large predators in the open ocean brings challenges, not least of which is finding willing human test subjects. *—Daniel Stone*

PHOTO: THOMAS P. PESCHAK

Watch the video of Food by the Numbers at **nationalgeographic.com/foodbynumbers.**

A Natural Solution

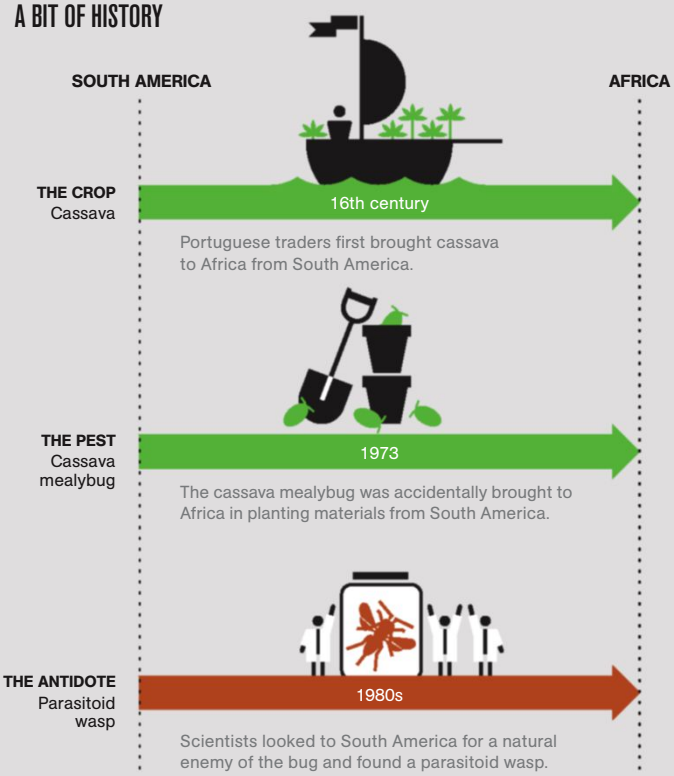
A growing number of farmers are managing agricultural pests with biopesticides and biological control agents, including natural materials such as plants, bacteria, and fungi. Predatory and parasitic insects are a form of biological control. All these methods work to keep pest levels low enough to minimize crop losses without posing a major threat to the environment.

Demand for produce free of pesticide residues is driving the increase in biopesticides, says Mark Davis of the UN Food and Agriculture Organization. Biopesticides are inherently less harmful to humans and break down more quickly than typical agrochemicals. According to Davis, some beneficial fungi even go beyond pest killing by liberating soil nutrients that promote plant growth. *—Kelsey Nowakowski*

THE CASSAVA CASE

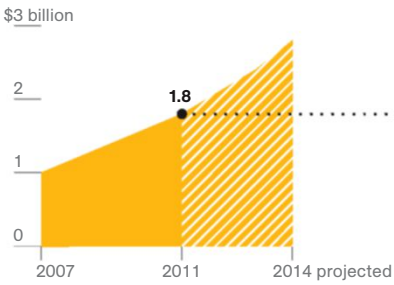
Cassava's starchy roots are a staple for millions of Africans, but cassava mealybugs ravaged the continent's crops in the 1970s and 1980s, decreasing yields by up to 80 percent. Scientists found a solution in natural pest management.

A BIT OF HISTORY

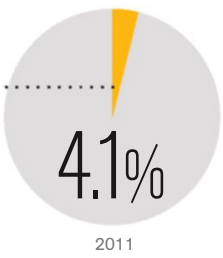


BIOPESTICIDE SALES

BIOPESTICIDE SALES ARE GROWING…

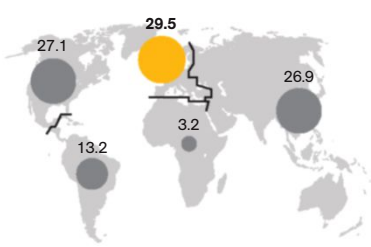


BUT ARE STILL A SMALL PART OF THE TOTAL PESTICIDE MARKET

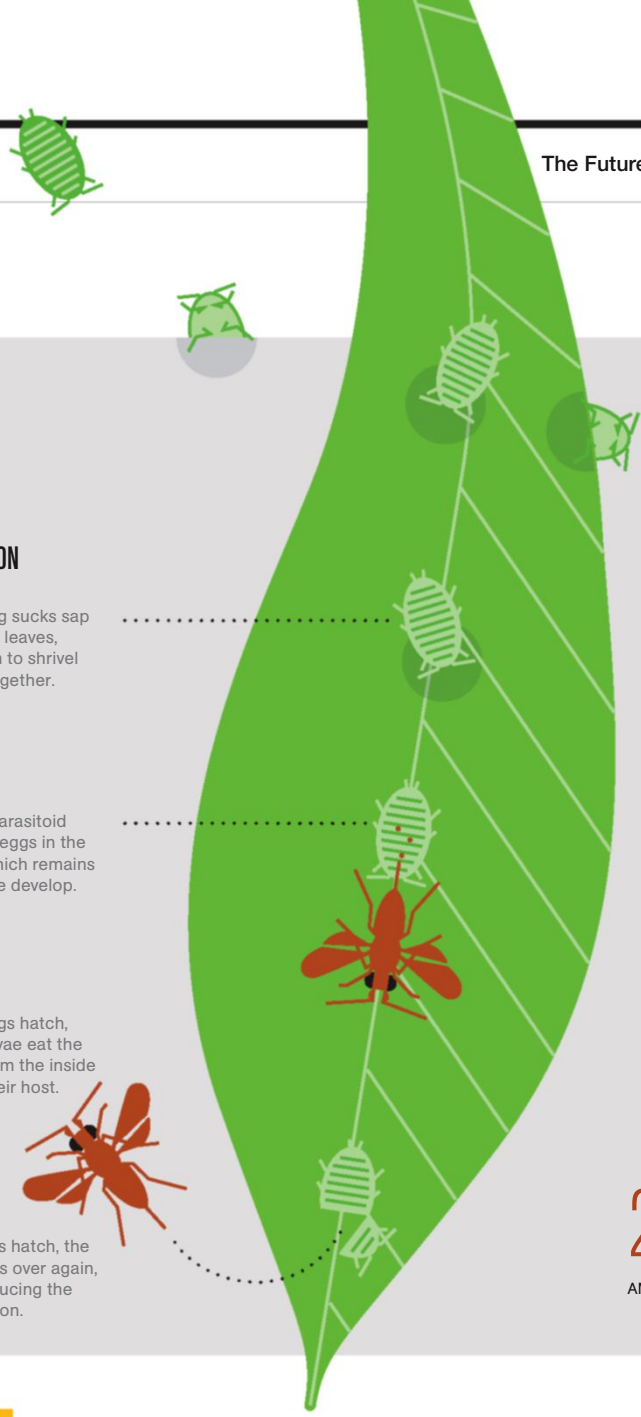


TOP MARKETS

PERCENTAGE OF BIOPESTICIDE SALES BY REGION, 2011



Biopesticide statistics include invertebrates.



NATURE IN ACTION

A The mealybug sucks sap from cassava leaves, causing them to shrivel and clump together.

B The female parasitoid wasp lays its eggs in the mealybug, which remains alive as larvae develop.

C When the eggs hatch, emerging larvae eat the mealybug from the inside out, killing their host.

D As new wasps hatch, the process starts over again, gradually reducing the pest population.

ECONOMIC BENEFIT

For every

$1

spent on biological control

$150

was returned to cassava farmers

2-4 YEARS

AMOUNT OF TIME IT TAKES TO FULLY MANAGE MEALYBUG INFESTATION

SALES BY TYPE

2011 WORLDWIDE SALES, IN MILLIONS (U.S. DOLLARS)



BIOCHEMICALS
$608
Includes substances such as scented plant extracts

MICROBIALS
$524
Includes bacteria ($339), fungi ($128), and viruses ($57)

INVERTEBRATES
$479
More than 300 species, such as parasitoid wasps and ladybugs

OTHER
$223
Includes phero-mones ($199) and nematodes ($24)



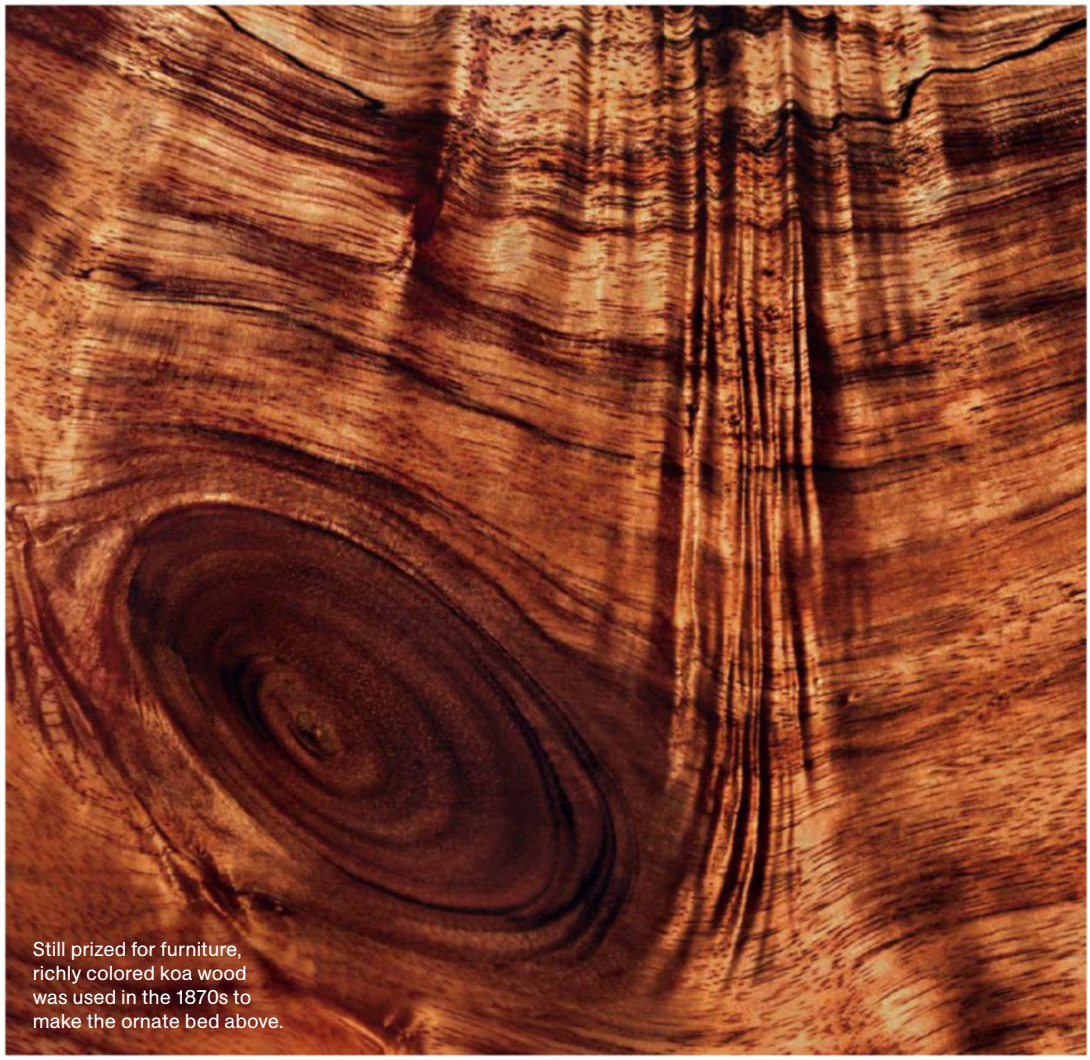
GRAPHICS: ÁLVARO VALIÑO. SOURCES: CPL BUSINESS CONSULTANTS; INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

Forest Revival

Koa is the king of Hawaii's endemic forests, the only places it grows. Reaching up to a hundred feet tall, these flowering trees once provided wood for native islanders' canoes and surfboards. But more than two centuries of logging and clearing the land for grazing have reduced koa forests to about 215,000 acres, perhaps half their original expanse.

To reverse this decline, private landowners and state and federal governments have planted hundreds of thousands of trees over the past 35 years. The new koa forests attract birds, insects, and plants—and improve watersheds, which helps humans too. *—A. R. Williams*





Still prized for furniture, richly colored koa wood was used in the 1870s to make the ornate bed above.

PHOTOS: PHOTO RESOURCE HAWAII/ALAMY; TODD A. GIPSTEIN, NATIONAL GEOGRAPHIC CREATIVE (TOP)

"I WAS PRESCRIBED LYRICA FOR MY **DIABETIC NERVE PAIN** AND IT HELPED ME. I'M GRATEFUL FOR IT."

—MICHAEL, FORMER PRO GOLFER
DIAGNOSED WITH DIABETIC NERVE PAIN.







Artist depiction

Diabetes damages nerves which may cause pain.

Lyrica is FDA approved to treat Diabetic Nerve Pain.

Get specific treatment for Diabetic Nerve Pain.

LYRICA® PREGABALIN Ⓒ capsules

Diabetic Nerve Pain (or pain from Diabetic Peripheral Neuropathy) is characterized by shooting, burning, pins and needles symptoms.

Lyrica has been clinically proven to provide effective pain relief so patients felt better.*

Some patients also had a significant reduction of pain in as early as one week. And, Lyrica is not a narcotic.**

Ask your doctor about Lyrica today.

*Individual results may vary. **Those who have had a drug or alcohol problem may be more likely to misuse Lyrica.
We asked Michael to tell us about his experience with Lyrica. To hear Michael's story, visit Lyrica.com.

Prescription Lyrica is not for everyone. Tell your doctor right away about any serious allergic reaction that causes swelling of the face, mouth, lips, gums, tongue, throat, or neck or any trouble breathing, rash, hives or blisters. Lyrica may cause suicidal thoughts or actions in a very small number of people. Patients, family members or caregivers should call the doctor right away if they notice suicidal thoughts or actions, thoughts of self harm, or any unusual changes in mood or behavior. These changes may include new or worsening depression, anxiety, restlessness, trouble sleeping, panic attacks, anger, irritability, agitation, aggression, dangerous impulses or violence, or extreme increases in activity or talking. If you have suicidal thoughts or actions, do not stop Lyrica without first talking to your doctor. Lyrica may cause swelling of your hands, legs and feet. Some of the most common side effects of Lyrica are dizziness and sleepiness. Do not drive or work with machines until you know how Lyrica affects you. Other common side effects are blurry vision, weight gain, trouble concentrating, dry mouth, and feeling "high." Also, tell your doctor right away about muscle pain along with feeling sick and feverish, or any changes in your eyesight including blurry vision or any skin sores if you have diabetes. You may have a higher chance of swelling, hives or gaining weight if you are also taking certain diabetes or high blood pressure medicines. Do not drink alcohol while taking Lyrica. You may have more dizziness and sleepiness if you take Lyrica with alcohol, narcotic pain medicines, or medicines for anxiety. If you have had a drug or alcohol problem, you may be more likely to misuse Lyrica. Tell your doctor if you are planning to father a child. Talk with your doctor before you stop taking Lyrica or any other prescription medication.

Please see Important Risk Information for Lyrica on the following page.

To learn more visit www.lyrica.com or call toll-free 1-888-9-LYRICA (1-888-959-7422).

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/medwatch or call 1-800-FDA-1088.

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IMPORTANT FACTS

LYRICA® PREGABALIN © capsules (LEER-i-kah)

IMPORTANT SAFETY INFORMATION ABOUT LYRICA

LYRICA may cause serious, even life threatening, allergic reactions.
Stop taking LYRICA and call your doctor right away if you have any signs of a serious allergic reaction:
- Swelling of your face, mouth, lips, gums, tongue, throat or neck
- Have any trouble breathing
- Rash, hives (raised bumps) or blisters

Like other antiepileptic drugs, LYRICA may cause suicidal thoughts or actions in a very small number of people, about 1 in 500.
Call your doctor right away if you have any symptoms, especially if they are new, worse or worry you, including:
- suicidal thoughts or actions
- new or worse depression
- new or worse anxiety
- feeling agitated or restless
- panic attacks
- trouble sleeping
- new or worse irritability
- acting aggressive, being angry, or violent
- acting on dangerous impulses
- an extreme increase in activity and talking
- other unusual changes in behavior or mood

If you have suicidal thoughts or actions, do not stop LYRICA without first talking to your doctor.

LYRICA may cause swelling of your hands, legs and feet.
This swelling can be a serious problem with people with heart problems.

LYRICA may cause dizziness or sleepiness.
Do not drive a car, work with machines, or do other dangerous things until you know how LYRICA affects you. Ask your doctor when it is okay to do these things.

ABOUT LYRICA

LYRICA is a prescription medicine used in adults 18 years and older to treat:
- Pain from damaged nerves that happens with diabetes or that follows healing of shingles, or spinal cord injury
- Partial seizures when taken together with other seizure medicines
- Fibromyalgia (pain all over your body)

Who should NOT take LYRICA:
- Anyone who is allergic to anything in LYRICA

BEFORE STARTING LYRICA

Tell your doctor about all your medical conditions, including if you:
- Have had depression, mood problems or suicidal thoughts or behavior
- Have or had kidney problems or dialysis
- Have heart problems, including heart failure
- Have a bleeding problem or a low blood platelet count
- Have abused prescription medicines, street drugs or alcohol in the past
- Have ever had swelling of your face, mouth, tongue, lips, gums, neck, or throat (angioedema)
- Plan to father a child. It is not known if problems seen in animal studies can happen in humans.
- Are pregnant, plan to become pregnant or are breastfeeding. It is not known if LYRICA will harm your unborn baby. You and your doctor should decide whether you should take LYRICA or breast-feed, but you should not do both.

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal supplements. LYRICA and other medicines may affect each other causing side effects. Especially tell your doctor if you take:

BEFORE STARTING LYRICA, continued

- Angiotensin converting enzyme (ACE) inhibitors. You may have a higher chance for swelling and hives.
- Avandia® (rosiglitazone)*, Avandamet® (rosiglitazone and metformin)* or Actos® (pioglitazone)** for diabetes. You may have a higher chance of weight gain or swelling of your hands or feet.
- Narcotic pain medicines (such as oxycodone), tranquilizers or medicines for anxiety (such as lorazepam). You may have a higher chance for dizziness and sleepiness.
- Any medicines that make you sleepy.

POSSIBLE SIDE EFFECTS OF LYRICA

LYRICA may cause serious side effects, including:
- See "Important Safety Information About LYRICA."
- Muscle problems, pain, soreness or weakness along with feeling sick and fever
- Eyesight problems including blurry vision
- Weight gain. Weight gain may affect control of diabetes and can be serious for people with heart problems.
- Feeling "high"

If you have any of these symptoms, tell your doctor right away.

The most common side effects of LYRICA are:
- Dizziness
- Blurry vision
- Weight gain
- Sleepiness
- Trouble concentrating
- Swelling of hands and feet
- Dry mouth

If you have diabetes, you should pay extra attention to your skin while taking LYRICA.

HOW TO TAKE LYRICA

Do:
- Take LYRICA exactly as your doctor tells you. Your doctor will tell you how much to take and when to take it. Take LYRICA at the same times each day.
- Take LYRICA with or without food.

Don't:
- Drive a car or use machines if you feel dizzy or sleepy while taking LYRICA.
- Drink alcohol or use other medicines that make you sleepy while taking LYRICA.
- Change the dose or stop LYRICA suddenly. If you stop taking LYRICA suddenly, you may have headaches, nausea, diarrhea, trouble sleeping, increased sweating, or you may feel anxious. If you have epilepsy, you may have seizures more often.
- Start any new medicines without first talking to your doctor.

NEED MORE INFORMATION?

- Ask your doctor or pharmacist. This is only a brief summary of important information.
- Go to **www.lyrica.com** or call **1-866-459-7422 (1-866-4LYRICA).**

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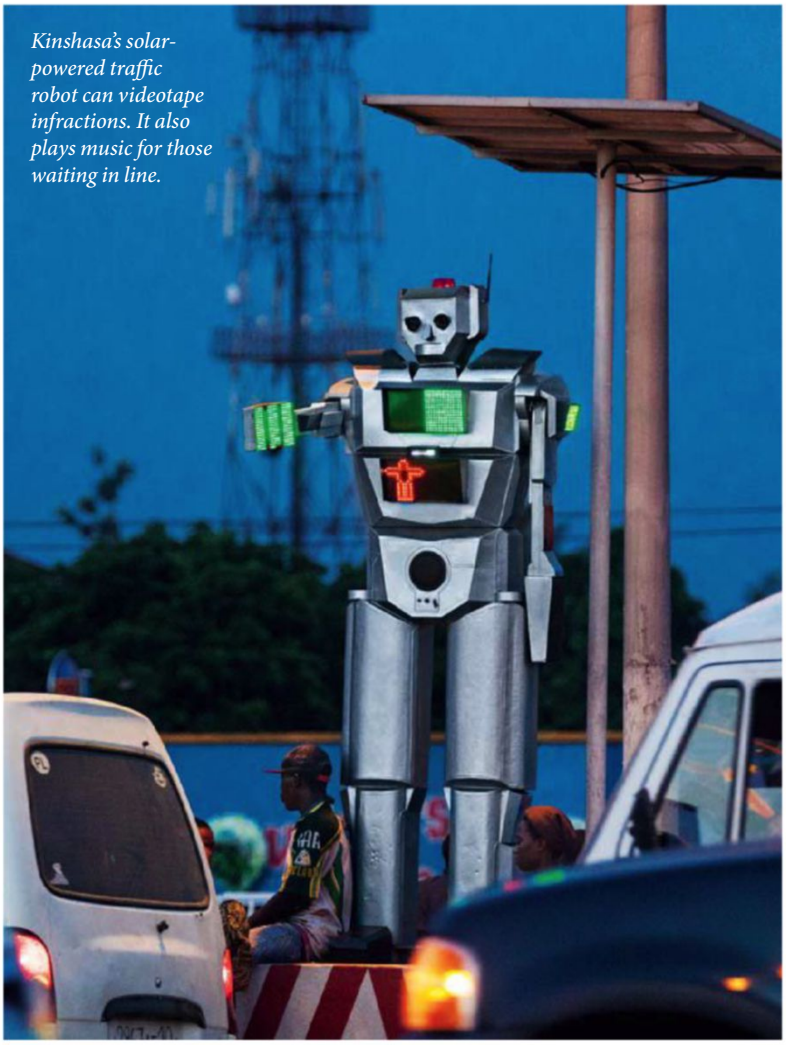
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Flamingos likely stand on one leg to conserve body heat.



Kinshasa's solar-powered traffic robot can videotape infractions. It also plays music for those waiting in line.

Obey the Robot

"Drivers, you can make way for pedestrians," booms a deep Darth Vader voice (in French) on Kinshasa's busy Lumumba Boulevard. Cars halt, people cross safely. *Incroyable.*

Meet the traffic cop of the future. It's an eight-foot-tall aluminum robot with cameras for eyes and fists of green and red lights, deployed to pacify the gridlocked, ticket-evading capital of the Democratic Republic of the Congo.

Its success delights Thérèse Izay Kirongozi of Women's Technology, the engineering co-op that designed and built the robot for $15,000. So far the city has installed two. Kirongozi, who counts 600 bad intersections, expects to sell more.

Some grouse that robots can't make arrests. Then again, they don't take bribes. *—Tom O'Neill*

Ancient Tines **Witness one of the first table forks. This Persian specimen—perhaps 15 centuries old, thought to have been found in 1930s Iraq—is on display at Dumbarton Oaks museum in Washington, D.C. Curator John Hanson says it likely survived because it's silver, not wood. "Archaeology favors the rich."** ***—Catherine Zuckerman***



PHOTOS: PASCAL MAITRE (TOP); REBECCA HALE, NGM STAFF. ART: ÁLVARO VALIÑO

KEEP IT WILD



01

Push yourself. Over rocks, over snow, over mud, over sand. Into the heart of no-man's-land. 4Runner and its available Multi-terrain Select are made to take thrill-seekers like you across all kinds of off-road to untamed places where you can keep it wild.

03

TOYOTA | Let's Go Places

02

JOIN THE OFF-ROAD MOVEMENT AT FACEBOOK.COM/4RUNNER

37° 45' 48" N / 119° 00' 36" W

4RUNNER 2014

Prototype shown with options. Production model may vary. ©2014 Toyota Motor Sales, U.S.A., Inc.

About 95.6 million cats and 83.3 million dogs are household pets in the United States.

Depp Sea Creature

The 1990 movie *Edward Scissorhands* has had a brush with science. Researchers discovered a pincered marine animal that lived 500 million years ago and named it after Johnny Depp—the actor who played Scissorhands. Called *Kootenichela deppi,* it likely used its clawlike extremities for foraging. *K. deppi* is the ancestor of all arthropods, says paleobiologist David Legg, "a group that's conquered most of Earth's ecosystems, including the depths of the Mariana Trench and the slopes of Mount Everest." *—Catherine Zuckerman*



About the size of an earthworm, Kootenichela deppi *was found fossilized in British Columbia's Kootenay National Park.*

THE LIST

Good Luck

Often originating in hunting or the performing arts, modern idioms for good luck frequently incorporate wishing exactly the opposite—to avoid a jinx. *—Johnna Rizzo*

ITALY ***in bocca al lupo***
in the mouth of the wolf

To avoid hexing a hunt, Italians wish for a wolf to eat the hunter himself. The response: I hope it dies.

RUSSIA ***ni pukha, ni pera***
neither wool, nor feather

Russians express a hope for an empty game bag to avoid obstructing a hunt's success.

VENEZUELA ***mucha mierda***
much excrement

Venezuelans borrow from a historical wish that many carriages—and their horses—will stop at a performance.

ESTONIA ***kivi kotti***
a stone into your bag

Also born of bestowing luck on a hunt, this Estonian wish is for heavy rocks to slow a hunter's progress.

U.S.A. ***break a leg***

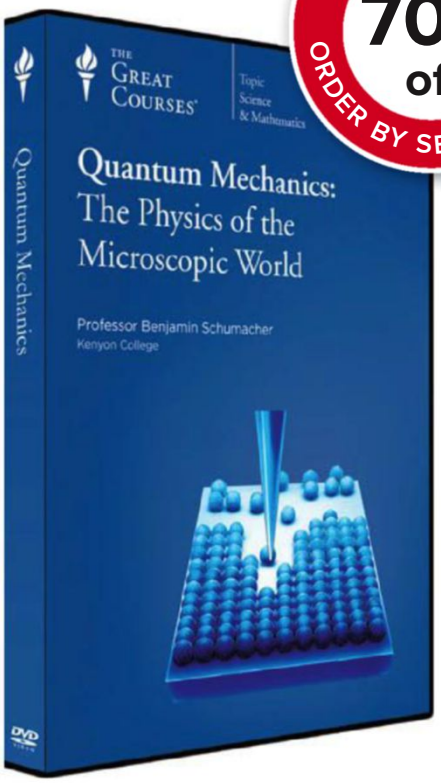
The American saying started as a superstition of performing artists—wishing something horrible so they wouldn't ruin a performance.

KOREA ***hwaiting***
fighting

To wish luck—often for sports or exams—Koreans mimic how Japanese pronounce "fighting."

ART: JOSÉ MIGUEL MAYO. GRAPHIC: ÁLVARO VALIÑO. SOURCE: HUMANE SOCIETY

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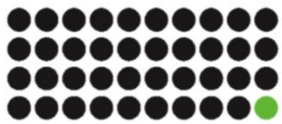
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SLOW POUR

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PEA-NUTS

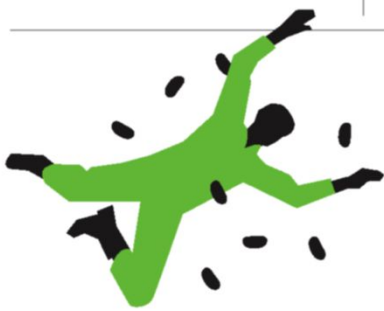
IDENTITY CRISIS

Peanuts are not nuts; they're legumes.



AFRICAN CHOCOLATE

West Africa produces nearly 70 percent of the world's cocoa.



SPATIAL POTATOES

Potato plants were grown aboard the space shuttle *Columbia* in 1995.



A LITTLE SPICY

Size is a general indicator of chili heat: the smaller, the hotter.



FIRST COOKBOOK

The year the first American cookbook—called, appropriately, *American Cookery*—was published



PURPLE CARROTS

Carrots were once largely yellow, red, or purple. Today's orange color dates only from the 19th century.

ART: ÁLVARO VALIÑO. PHOTO ILLUSTRATION: REBECCA HALE, NGM STAFF


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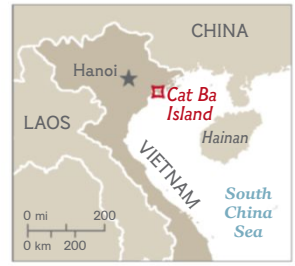
Eight of the 15 fastest-growing large U.S. cities in 2011–12 were in Texas.



Primate Rescue

The Cat Ba langur is one of the world's most critically endangered primates. The population of the raccoon-size Vietnamese species has dwindled from an estimated 2,500 in the 1960s to roughly 55 today, primarily due to poaching. Researchers had noticed a decline but didn't know how dramatic it was until a 1999 census was taken.

But the species may be headed for a revival. To deter hunters, the Vietnamese government established a core protected area within a national park. Biologists with the Cat Ba Langur Conservation Project have moved two females to the area to spur more births. Some locals are even helping by recording sightings. "At this point," says zoologist Rick Passaro, "the numbers are poised not to explode, but certainly to take off." *—Daniel Stone*



Cat Ba langurs (top), found only on Vietnam's Cat Ba Island, were hunted for use in traditional medicine.

ET CETERA

The brains of **BALLET DANCERS** become desensitized to dizziness. The discovery may hold clues for treating vertigo. ▪ Teeth of marine mollusks are made of **MAGNETITE** and are harder than the teeth of any other organism. ▪ An Israeli botanist has successfully grown an extinct **JUDAEAN DATE PALM TREE** from 2,000-year-old seeds discovered by archaeologists. ▪ Water filters made of **CILANTRO** were shown to be highly absorbent, able to remove heavy metals such as lead from drinking water.

PHOTO: MAI SY LUAN, CAT BA LANGUR CONSERVATION PROJECT. ART: ÁLVARO VALIÑO. NGM MAPS

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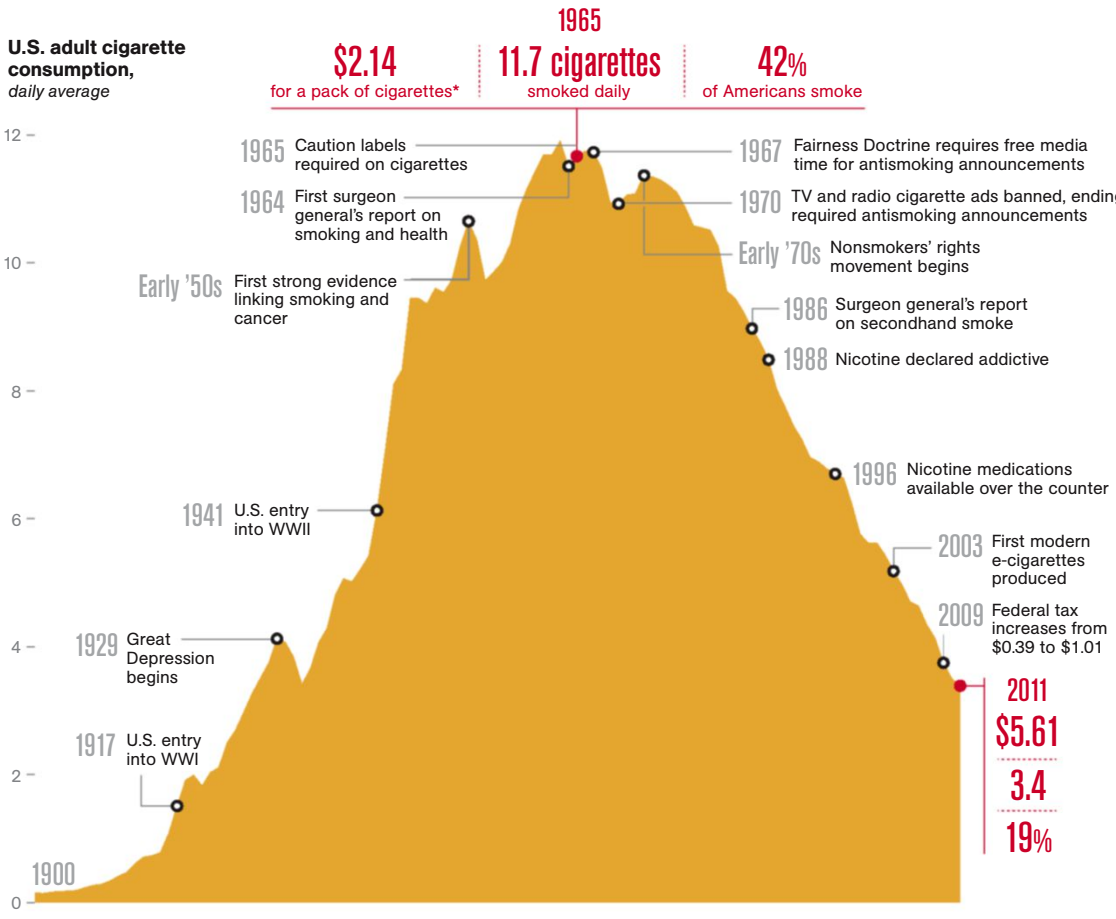


Smoked Out

We've come a long way, baby. In 1931 doctors promoted cigarettes (left). In 1965, the year after Surgeon General Luther Terry's landmark report linked smoking to lung cancer and heart disease, 42 percent of U.S. adults puffed daily. By 2012, just 18 percent were lighting up.

Now for the bad news. Smoking can also cause diabetes, liver and colorectal cancer, pregnancy problems, and many other ills, says Jonathan Samet, editor of this year's report. It's killed 20 million in 50 years. Changes like ventilated filters make cigarettes more toxic than ever. And smoking is bad for fiscal health, costing $300 billion a year in medical bills and lost productivity.

Smokeless options like e-cigarettes—their safety is not yet known, but federal regulation is pending—could be less harmful, says David Abrams of the Schroeder Institute. "Burning tobacco releases carcinogens and causes most of the damage. It's time to make combusted cigarettes obsolete." *—Jeremy Berlin*



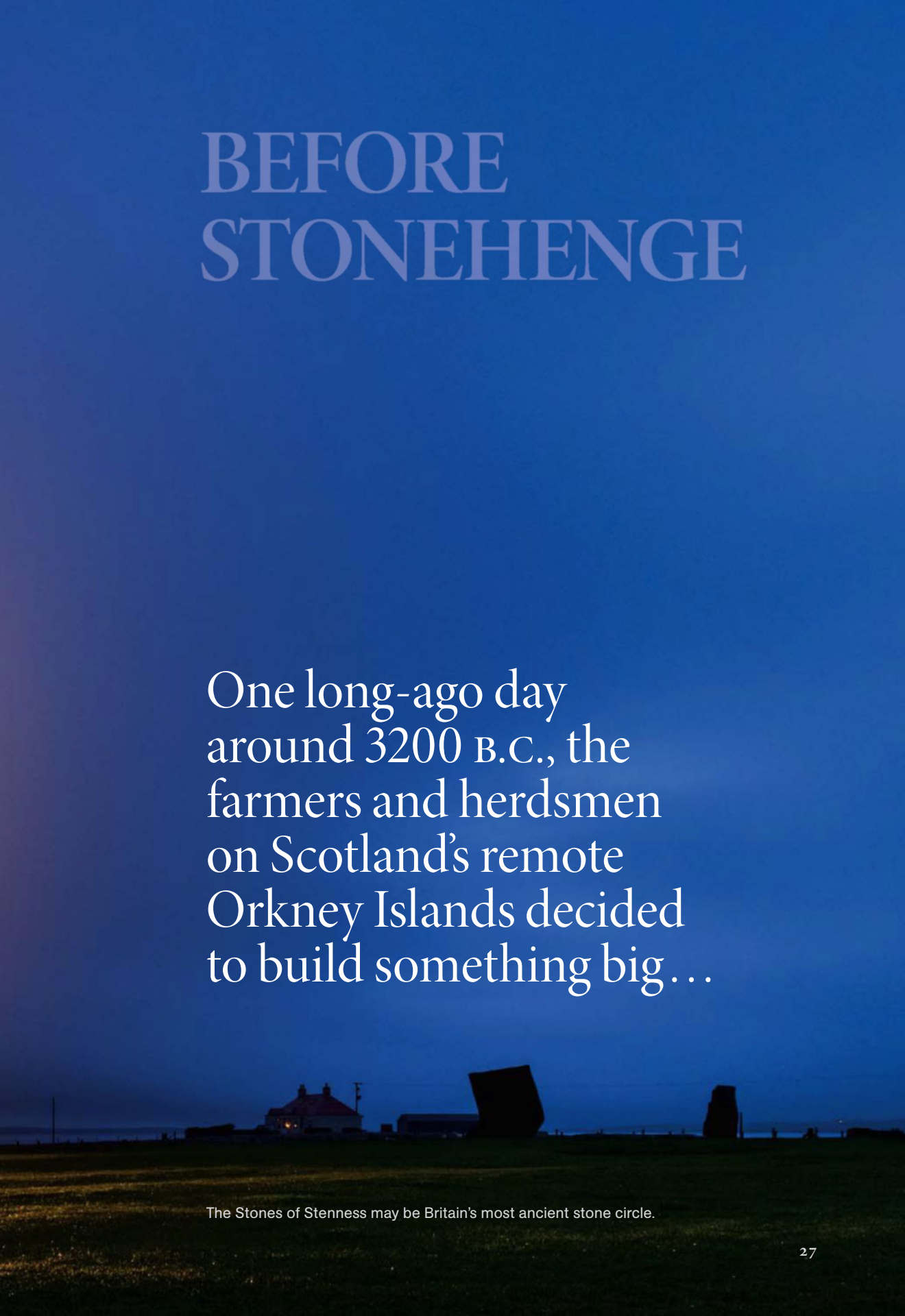
*In 2011 dollars

PHOTO: R. J. REYNOLDS TOBACCO COMPANY/STANFORD SCHOOL OF MEDICINE. GRAPHIC: LAWSON PARKER, NGM STAFF
SOURCES: U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES; CENTERS FOR DISEASE CONTROL AND PREVENTION; NATIONAL CENTER FOR CHRONIC DISEASE PREVENTION AND HEALTH PROMOTION; OFFICE ON SMOKING AND HEALTH



BEFORE STONEHENGE

One long-ago day around 3200 B.C., the farmers and herdsmen on Scotland's remote Orkney Islands decided to build something big…



The Stones of Stenness may be Britain's most ancient stone circle.





Life in Stone Age Orkney was far more refined than once imagined. The well-built homes at Skara Brae, Europe's most complete Neolithic village, included stone hearths, beds, and cupboards.

SITES AND ARTIFACTS PHOTOGRAPHED WITH PERMISSION OF HISTORIC SCOTLAND





Blessed with fertile soil and a mild climate, Orkney was a land of plenty for Neolithic homesteaders. Agricultural wealth helped give them the freedom to pursue grand architectural dreams.

By Roff Smith | Photographs by Jim Richardson

They had Stone Age technology, but their vision was millennia ahead of their time. Five thousand years ago the ancient inhabitants of Orkney—a fertile, green archipelago off the northern tip of modern-day Scotland—erected a complex of monumental buildings unlike anything they had ever attempted before.

They quarried thousands of tons of fine-grained sandstone, trimmed it, dressed it, then transported it several miles to a grassy promontory with commanding views of the surrounding countryside. Their workmanship was impeccable. The imposing walls they built would have done credit to the Roman centurions who, some 30 centuries later, would erect Hadrian's Wall in another part of Britain.

Cloistered within those walls were dozens of buildings, among them one of the largest roofed structures built in prehistoric northern Europe. It was more than 80 feet long and 60 feet wide, with walls 13 feet thick. The complex featured paved walkways, carved stonework, colored facades, even slate roofs—a rare extravagance in an age when buildings were typically roofed with sod, hides, or thatch.

Fast-forward five millennia to a balmy summer afternoon on a scenic headland known as the Ness of Brodgar. Here an eclectic team of archaeologists, university professors, students, and volunteers is bringing to light a collection of grand buildings that long lay hidden beneath a farm field. Archaeologist Nick Card, excavation director with the Archaeology Institute at the University of the Highlands and Islands, says the recent discovery of these stunning ruins is turning British prehistory on its head.

"This is almost on the scale of some of the great classical sites in the Mediterranean, like the Acropolis in Greece, except these structures are 2,500 years older. Like the Acropolis, this was built to dominate the landscape—to impress, awe, inspire, perhaps even intimidate anyone who saw it. The people who built this thing had big ideas. They were out to make a statement."

What that statement was, and for whom it was intended, remains a mystery, as does the purpose of the complex itself. Although it's usually referred to as a temple, it's likely to have fulfilled a variety of functions during the thousand years it was in use. It's clear that many people gathered here for seasonal rituals, feasts, and trade.

The discovery is all the more intriguing because the ruins were found in the heart of one of the densest collections of ancient monuments in Britain. The area has been searched for the past 150 years, first by Victorian antiquarians, later by archaeologists. Yet none of them had the slightest idea what lay beneath their feet.

Stand at "the Ness" today and several iconic Stone Age structures are within easy view, forming the core of a World Heritage site called the Heart of Neolithic Orkney. On a heather-clad knoll half a mile away rises a giant Tolkienesque circle of stones known as the Ring of Brodgar. A second ceremonial stone circle, the famous Stones of Stenness, is visible across the causeway leading up to the Ness. And one mile away is an eerie mound called Maes Howe, an enormous chambered tomb more than 4,500 years old. Its entry passage is perfectly aligned to receive the rays of the setting sun on the eve of the winter solstice, illuminating its inner chamber on the shortest day of the year.

Maes Howe also aligns with the central axis and entrance to the newly discovered temple

Roff Smith regularly explores the English countryside on a bicycle. Jim Richardson has photographed more than 25 articles for National Geographic.



Archaeologists excavating the Ness of Brodgar uncovered the richest collection of Neolithic art yet found in Britain, including this decorative stone incised with a geometric motif.

on the Ness, something archaeologists believe is no coincidence. They suspect that the freshly uncovered ruins may be a key piece to a larger puzzle no one dreamed existed.

Until as recently as 30 years ago, the Ring of Brodgar, the Stones of Stenness, and the Maes Howe tomb were seen as isolated monuments with separate histories. "What the Ness is telling us is that this was a much more integrated landscape than anyone ever suspected," says Card. "All these monuments are inextricably linked in some grand theme we can only guess at. And the people who built all this were a far more complex and capable society than has usually been portrayed."

ORKNEY HAS LONG BEEN GOOD to archaeologists, thanks to its deep human history and the fact that nearly everything here is built of stone. Literally thousands of sites are scattered through the islands, the majority of them untouched. Together they cover a great sweep of time and settings, from Mesolithic camps and Iron Age settlements to the remains of Old Norse feasting halls and ruined medieval palaces.

"I've heard this place called the Egypt of the North," says county archaeologist Julie Gibson, who came to Orkney more than 30 years ago to excavate a Viking cemetery and never left. "Turn over a rock around here and you're likely to find a new site."

NESS OF BRODGAR PHOTOGRAPHED WITH PERMISSION OF THE ARCHAEOLOGY INSTITUTE, UNIVERSITY OF THE HIGHLANDS AND ISLANDS



Student Jessica "Jo" Heupel uncovers a polished stone axhead—"the finest one I've ever had the pleasure of seeing discovered," says excavation director Nick Card (left).

Sometimes you don't even need to do that. In 1850 a gale tore away some sand dunes along the Bay of Skaill, on the western flank of Mainland island, exposing an astonishingly well preserved Stone Age village. Archaeologists date the village, called Skara Brae, to around 3100 B.C. and believe it was occupied for more than 600 years.

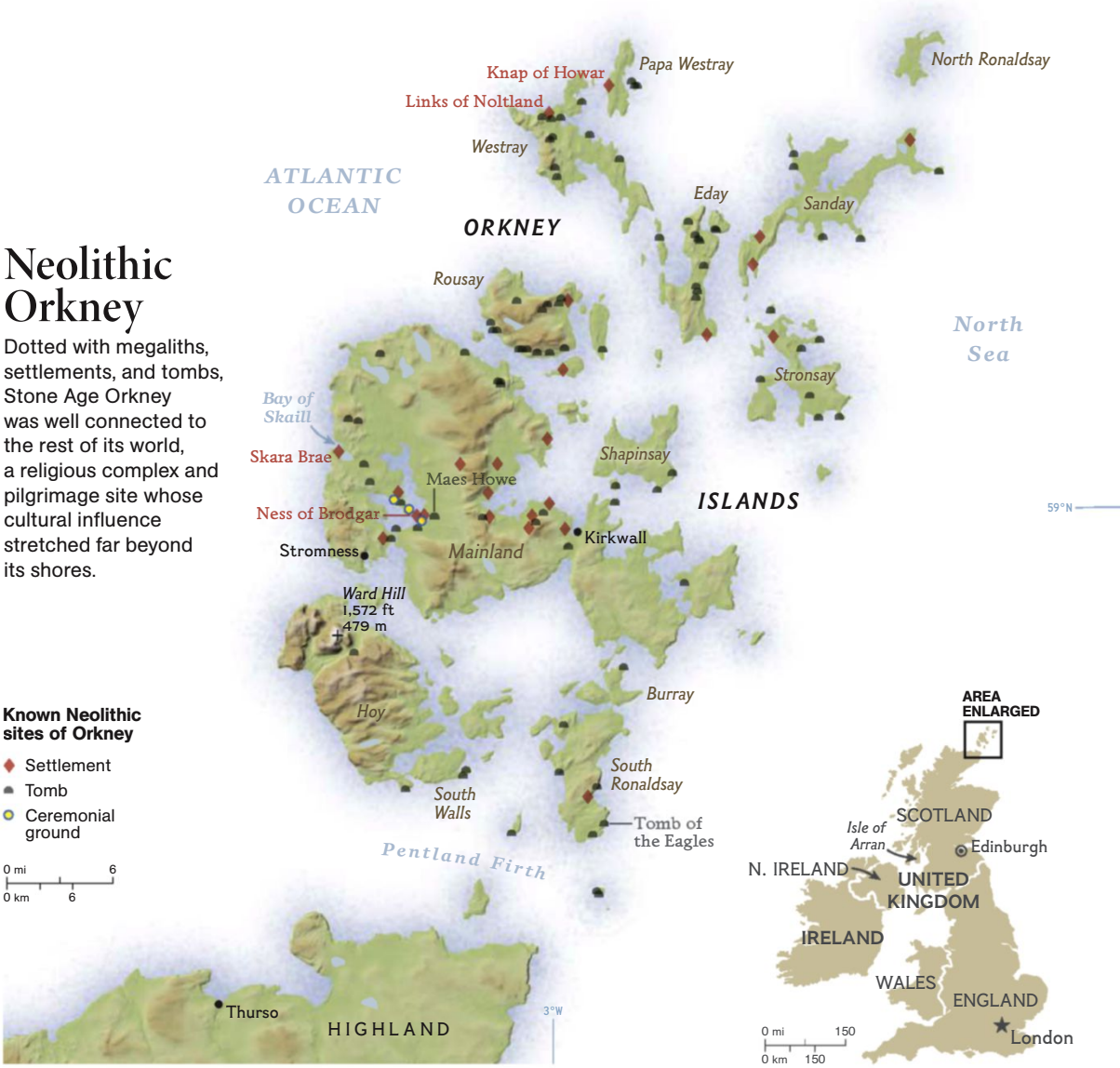
Skara Brae must have been a cozy setup in its day. Lozenge-shaped stone dwellings linked by covered passages huddled close together against the grim winters. There were hearths inside, and the living spaces were furnished with stone beds and cupboards. Even after the passage of thousands of years the dwellings look appealingly personal, as though the occupants had just stepped out. The stage-set quality of the homesteads and the glimpse they offer into everyday life in the Neolithic, to say nothing of the dramatic way they were revealed, made Skara Brae Orkney's most spectacular find. Until now.

THE FIRST HINT OF BIG THINGS underfoot at the Ness came to light in 2002, when a geophysical survey revealed the presence of large, man-made anomalies beneath the soil. Test trenches were dug and exploratory excavations begun, but it wasn't until 2008 that archaeologists began to grasp the scale of what they had stumbled upon.

Today only 10 percent of the Ness has been excavated, with many more stone structures

Neolithic Orkney

Dotted with megaliths, settlements, and tombs, Stone Age Orkney was well connected to the rest of its world, a religious complex and pilgrimage site whose cultural influence stretched far beyond its shores.



JEROME N. COOKSON, NGM STAFF. SOURCES: NICK CARD, ARCHAEOLOGY INSTITUTE, UNIVERSITY OF THE HIGHLANDS AND ISLANDS; CAROLINE WICKHAM-JONES, DEPARTMENT OF ARCHAEOLOGY, UNIVERSITY OF ABERDEEN; ROYAL COMMISSION ON THE ANCIENT AND HISTORICAL MONUMENTS OF SCOTLAND

known to be lurking under the turf nearby. But this small sample of the site has opened an invaluable window into the past and yielded thousands of priceless artifacts: ceremonial mace heads, polished stone axes, flint knives, a human figurine, miniature thumb pots, beautifully crafted stone spatulas, colored pottery far more refined and delicate than anyone had expected for its time, and more than 650 pieces of Neolithic art, by far the largest collection ever found in Britain.

Before visiting the Ness, I tended to view Stone Age sites with indifferent curiosity. The lives of the long-ago inhabitants seemed far removed and alien. But art offers a glimpse into the minds and imaginations of the people who create it. At the Ness I found myself looking into a world I could comprehend, even if its terms were radically different from my own.

"Nowhere else in all Britain or Ireland have such well-preserved stone houses from the Neolithic survived, so Orkney is already punching above its weight," says Antonia Thomas, an archaeologist at the University of the Highlands and Islands. "To be able to link these structures with art, to see in such a direct and personal way how people embellished their surroundings, is really something."

One of the more startling discoveries has been discernible traces *(Continued on page 46)*

Ness of Brodgar

Discovered little more than a decade ago, this mysterious temple complex is now believed to be the epicenter of what was once a vast ritualistic landscape. The site's extraordinary planning, craftsmanship, and thousand-year history are helping rewrite our entire understanding of Neolithic Britain.



CIRCA 2800 B.C.
The scene depicted here shows the Ness of Brodgar site in its heyday. The complex was remade several times and constantly evolved throughout its thousand-year period of use.

1. ANCIENT MARSHLAND
During the Neolithic, water levels were still rising after the last ice age, so the shore was lined with bogs and marshlands.

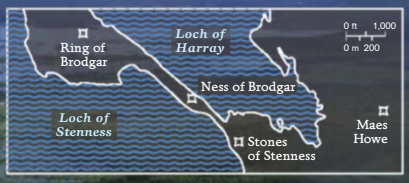
2. OUTDOOR RITUALS
Evidence suggests people didn't live here year-round but visited periodically, perhaps to make offerings as part of a ritual procession through the site and its many buildings.

3. ENCLOSED IN STONE
Roughly 10 feet high and up to 18 feet wide, these are some of the largest prehistoric walls ever found in Britain.

4. WHERE HEAVE AND EARTH MEE
Located in the center of the si and the surrou bowl of land, th standing stone aligned with the spring and fall equinoxes and might have serv as a symbolic axis between earth and sky.

KINDRED SITES
The Ring of Bro Ness of Brodga Stones of Stenn and Maes Howe likely formed a complex linked religious ritual.

JOHN TOMANIO, NGM STAFF; AMANDA HOBBS
ART: DYLAN COLE, NGM MAPS
SOURCE: NICK CARD, ARCHAEOLOGY INSTITUTE, UNIVERSITY OF THE HIGHLANDS AND ISLANDS



6

5. SOPHISTICATED BUILDING TECHNIQUES
The Ness provides the first evidence in northern Europe of roofs made of carefully trimmed, rectangular stone slates. Recent finds also indicate some walls may have been decorated with natural pigments and colored stones.

6. MORE THAN TRASH
Over 16 feet high, this midden pile is the biggest found in Neolithic Britain and may have had ceremonial functions involving fertility and cycles of life, death, decay, and renewal.

This domino-size figure is the earliest depiction of a human face found in Britain.



The sprawling excavation at the Ness of Brodgar was a farmer's backyard until a few years ago. Now the foundations of 25 structures have been exposed, with only about 10 percent of the site uncovered.

PANORAMA COMPOSED OF SIX IMAGES





Pins up to seven inches long made of bone and antler may have fastened a cloak.





Orkney's largest tomb, Maes Howe, is aligned to capture the rays of the setting sun on the eve of the winter solstice. "Orkney is a key to understanding Neolithic religion," says site director Nick Card.

PANORAMA COMPOSED OF SEVEN IMAGES

How did this scatter of islands become a technological, cultural, and spiritual powerhouse?



In 1958 a farmer digging flagstones accidentally uncovered the 5,000-year-old Tomb of the Eagles. It held more than 16,000 human bones mingled with the talons of white-tailed eagles.

(Continued from page 35) of colored pigments on some of the stonework. "I've always suspected that color played an important role in people's lives," says Card. "I had a sense that they painted their walls, but now we know for sure."

Indeed one of the structures apparently served as a kind of paint shop, complete with piles of pigment still on the floor: powdered hematite (red), ocher (yellow), and galena (white), together with the dimpled rocks and grinding stones that served as mortar and pestle.

Also found among the ruins were prized trade goods such as volcanic glass from as far afield as the Isle of Arran in western Scotland, and high-quality flints from across the archipelago and beyond. These artifacts suggest that Orkney was on an established trade route and that the temple complex on the Ness may have been a site of pilgrimage.

More intriguing than the items traders and pilgrims brought to the site, say archaeologists, is what they took away: ideas and inspiration. Distinctive colored pottery sherds found at the Ness and elsewhere, for example, suggest that the trademark style of grooved pottery that became almost universal throughout Neolithic Britain had its origin in Orkney. It may well be that rich and sophisticated Orcadians were setting the fashion agendas of the day.

"This is totally at odds with the old received



More than 20 feet tall and 100 feet in diameter, Maes Howe required thousands of man-hours to build and a disciplined society of architects, engineers, and laborers.

wisdom that anything cultural must have come from the genteel south to improve the barbarian north," laughs Roy Towers, a Scottish archaeological ceramicist and the site's pottery specialist. "It seems to have been just the reverse here."

Traders and pilgrims also returned home with recollections of the magnificent temple complex they had seen and notions about celebrating special places in the landscape the way the Orcadians did—ideas which, centuries later, would find their ultimate expression at Stonehenge.

WHY ORKNEY OF ALL PLACES? How did this scatter of islands off the northern tip of Scotland come to be such a technological, cultural, and spiritual powerhouse? "For starters, you have to stop thinking of Orkney as remote," says Caroline Wickham-Jones, a lecturer in archaeology at the University of Aberdeen. "For most of history, from the Neolithic to the Second World War, Orkney was an important maritime hub, a place that was on the way to everywhere."

It was also blessed with some of the richest farming soils in Britain and a surprisingly mild climate, thanks to the effects of the Gulf Stream. Pollen samples reveal that by about 3500 B.C.—around the time of the earliest settlement on Orkney—much of the hazel and birch woodland that originally covered the landscape was gone.

"It's been assumed that the woodland was

Sometime around the year 2300 B.C., for reasons that remain obscure, it all came to an end.



Sheep graze among the Stones of Stenness, which may have been a model for Stonehenge. In 1814 a farmer tried to remove the ancient stones so he could more easily tend his fields.

cleared away by Neolithic farmers, but that doesn't seem to have been entirely the case," says Michelle Farrell, a paleoecologist at Queen's University Belfast who studies past land use and environmental change. "Although early farmers accounted for a degree of woodland loss, in some areas much of the woodland was already gone by 5500 B.C. It seems to have been a prolonged event and largely caused by natural processes, but what those processes were we really can't say without better climate records."

One thing is certain, says Farrell: "The open nature of the landscape would have made life much easier for those early farmers. It could have been one of the reasons why they were able to devote so much time to monument building."

It's also clear that they had plenty of willing hands and strong backs to put to the cause. Estimates of Orkney's population in Neolithic times run as high as 10,000—roughly half the number of people who live there today—which no doubt helps account for the density of archaeological sites in the islands. Unlike other parts of Britain, where houses were built with timber, thatch, and other materials that rot away over time, Orcadians had abundant outcrops of fine, easily worked sandstone for building homes and temples that could last for centuries.

What's more, the Neolithic homesteaders and pioneers who settled Orkney knew what they

were doing. "Orkney's farmers were among the first in Europe to have deliberately manured their fields to improve their crops," says Jane Downes, director of the Archaeology Institute at the University of the Highlands and Islands. "Thousands of years later medieval peasants were still benefiting from the work those Neolithic farmers put into the soil."

They also imported cattle, sheep, goats, and possibly red deer, ferrying them out from the Scottish mainland in skin boats, braving miles of open water and treacherous currents. The herds they raised grew fat on the island's rich grazing. Indeed, to this day, Orkney beef commands a premium on the market.

In short, by the time they embarked on their ambitious building project on the Ness of Brodgar, Orkney's farmers had become wealthy and well established, with much to be grateful for and a powerful spiritual bond to the land.

FOR A THOUSAND YEARS, a span longer than Westminster Abbey and Canterbury Cathedral have stood, the temple complex on the Ness of Brodgar cast its spell over the landscape—a symbol of wealth, power, and cultural energy. To generations of Orcadians who gathered there, and to the travelers who came hundreds of miles to admire it and conduct business, the temple and its walled compound of buildings must have seemed as enduring as time itself.

But sometime around the year 2300 B.C., for reasons that remain obscure, it all came to an end. Climate change may have played a role. Evidence suggests that northern Europe became cooler and wetter toward the end of the Neolithic, and these conditions may have had a negative effect on agriculture.

Or perhaps it was the disruptive influence of a new toolmaking material: bronze. Not only did the metal alloy introduce better tools and weapons. It also brought with it fresh ideas, new values, and possibly a shake-up of the social order.

"We've not found any bronze artifacts so far on the Ness," says Card. "But a society as powerful and well connected as they were must surely have known that profound changes were coming their way. It may have been they were one of the holdouts."

Whatever the reason, the ancient temple was decommissioned and partially destroyed, deliberately and symbolically. Before the people moved on, they left behind one final startling surprise for archaeologists to find: the remains of a gargantuan farewell feast. More than 400 cattle were slaughtered, enough meat to have fed thousands of people.

"The bones all appear to have come from a single event," says Ingrid Mainland, an archaeozoologist from the University of the Highlands and Islands who specializes in ancient livestock. She has been analyzing the piles of bones that were deliberately arranged around the temple. Curiously, the people who ate that final feast left behind only the shinbones of the animals they slaughtered. "What the significance of the tibia was to them, where that fits in the story, is a mystery," says Mainland.

Another unknown is what impact killing so many cattle may have had on this agricultural community. "Were they effectively taking out the future productivity of their herds?" wonders Mainland. "We don't know."

After cracking open the bones to extract the rich marrow inside, the people arranged them in intricate piles around the base of the temple. Next they draped unbutchered deer carcasses over the piles, presumably as offerings. In the center of the chamber they deposited a cattle skull and a large stone engraved with a sort of cup motif. Then came the final act of closure.

"They deliberately demolished the buildings and buried them under thousands of tons of rubble and trash," says Card. "It seems that they were attempting to erase the site and its importance from memory, perhaps to mark the introduction of new belief systems."

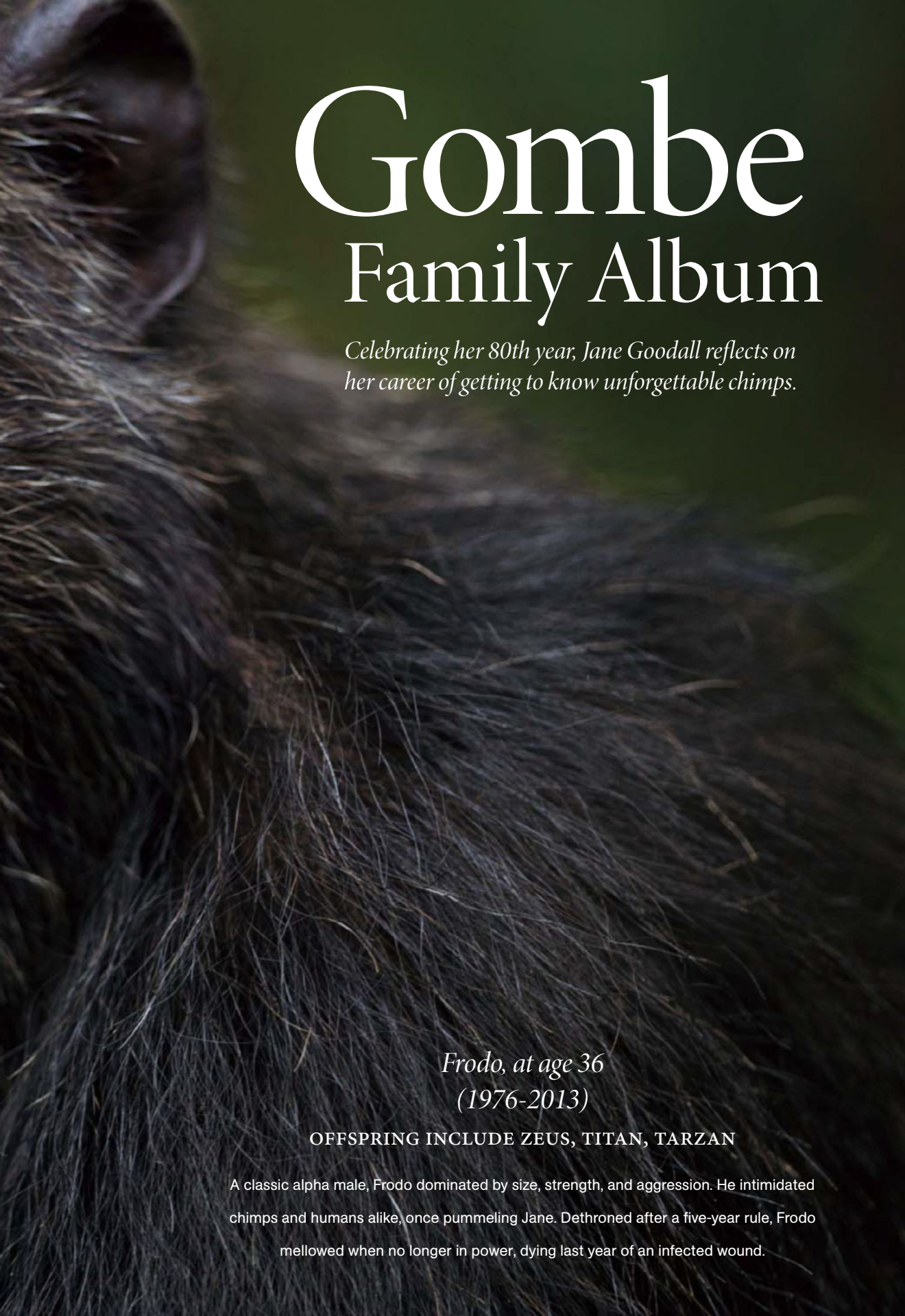
Over the centuries that followed the abandonment of the Ness, time and the elements took their toll. Whatever stones remained visible from the old forgotten walls were carried away by homesteaders for use in their own cottages and farms. Now it was their turn to play out their history on Orkney's windswept stage. □





Last of the great monuments built on the Ness, the Ring of Brodgar has inspired awe for 4,500 years. As Scottish poet George Mackay Brown wrote, “The Orkney imagination is haunted by time.”





Gombe Family Album

Celebrating her 80th year, Jane Goodall reflects on her career of getting to know unforgettable chimps.

Frodo, at age 36
(1976-2013)

OFFSPRING INCLUDE ZEUS, TITAN, TARZAN

A classic alpha male, Frodo dominated by size, strength, and aggression. He intimidated chimps and humans alike, once pummeling Jane. Dethroned after a five-year rule, Frodo mellowed when no longer in power, dying last year of an infected wound.

By David Quammen
Photographs by Anup Shah and Fiona Rogers

On April 3, 2014, Jane Goodall turned 80. The iconic blond ponytail has gone gray, but the sparkle of intelligence, sly humor, and fierce dedication still shines from her hazel eyes. My conversation with Jane began in connection with the 50th anniversary of the Gombe, Tanzania, chimp study (see "Jane: Fifty Years at Gombe," October 2010) and resumed this year at National Geographic, where we riffled through Anup Shah's photographs and Jane's memories. Her work with chimps began in July 1960, and within months she had become familiar with several individuals. She soon made three major discoveries: Chimpanzees use tools, chimpanzees make tools, chimpanzees can be predators and eat meat. She also began to recognize the degree of individual difference—unique personality traits—between one chimp and another. Then, in 1962, she took leave to earn a Ph.D. in ethology (animal behavior) at Cambridge University.

JANE GOODALL In those days, you know, ethology was really trying to prove that it was a hard science. Which of course it can't really be. Not unless you're very invasive. And so, although individual differences were sort of admitted, they were not discussed.

DAVID QUAMMEN Academic ethology didn't like to talk about individual differences. It liked patterns.

JG It was very reductionist.

DQ Reducing individuals and their behavior to data and the patterns that can be drawn from data.

JG Right. And anecdotes were absolutely the worst sin.

DQ And you came along and wanted to talk about individuals, and about personalities and about character.

JG I wanted to talk about emotions. I wanted to talk about the mind, and thoughts.

DQ How did that play out at Cambridge?

The answer was, not well. Her professors disapproved of her approach.

JG It was a bit shocking to be told I'd done everything wrong. Everything. I shouldn't have given them names. I couldn't talk about their personalities, their minds, or their feelings. Those are unique to us. Fortunately, I thought back to my first teacher, when I was a child, who taught me that that wasn't true. And that was my dog, Rusty. You cannot share your life in a meaningful way with any kind of animal with a reasonably well developed brain and not realize that animals have personalities.

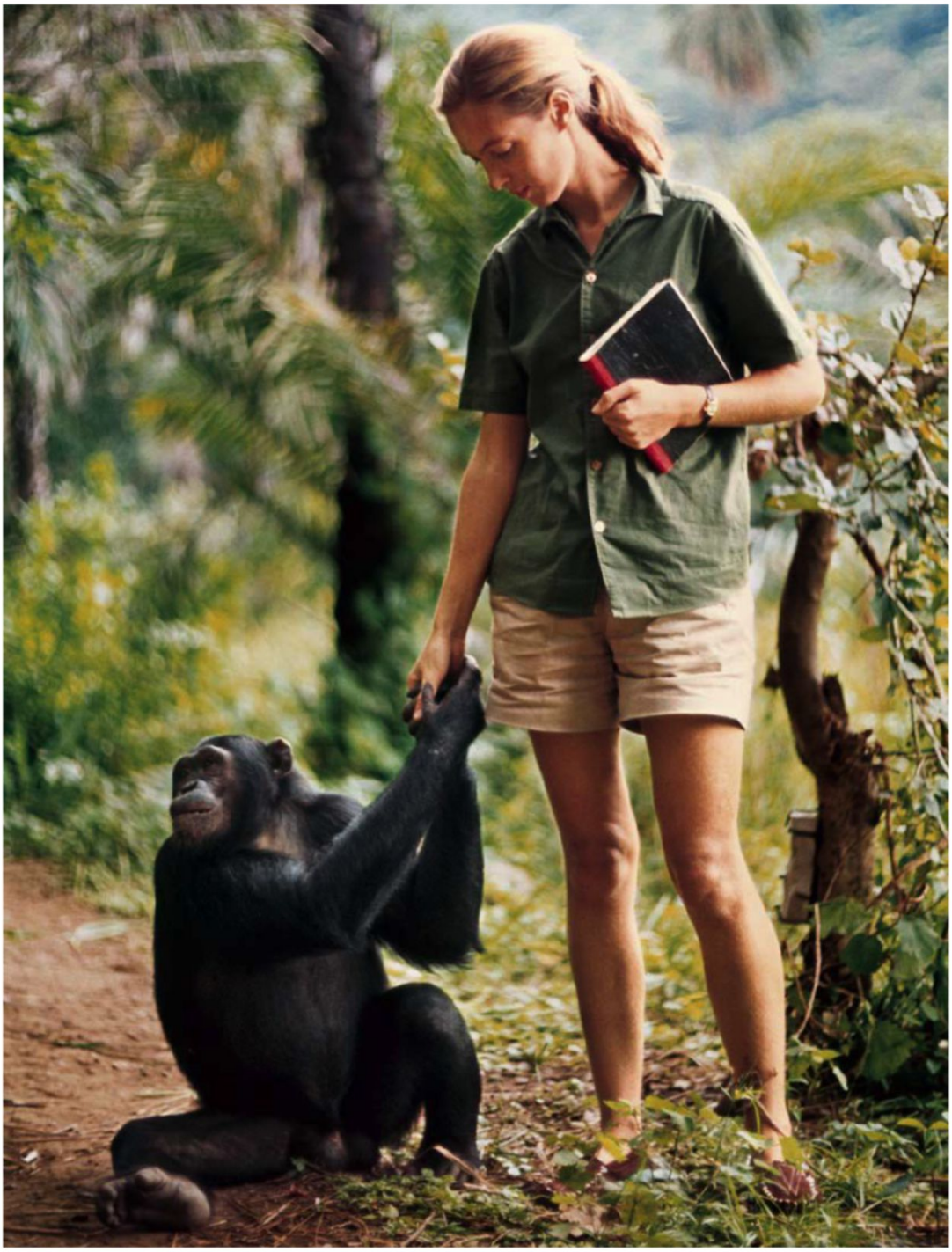
So Jane and I talk not about patterns or ideas, but about the individual characters of certain Gombe chimps, including some in the photos on these pages.

DQ How would you describe David Greybeard?

JG His personality was very calm. Very determined. When he was determined, his lower lip came out. Like that.

She pouts out her lip, mimicking the gesture. I ask about Goliath, the alpha male of the community during her first years.

JG Goliath was tempestuous. He was very brave. I say "brave" advisedly, because he would stand up to anyone challenging him, even though they were bigger, even though



GOMBE Close observation and warm sensitivity went hand in hand during Jane Goodall's pioneering work. Here, in the early 1960s, she connects with Figan, an adolescent that would graduate to alpha male.

HUGO VAN LAWICK, NATIONAL GEOGRAPHIC CREATIVE

there were two of them. So he wasn't calm at all, like David.

DQ What sort of relationship did they have with each other?

JG I think they must have been siblings. They were just together so often. And David was very reassuring to Goliath when he was being challenged. It was so awful that Goliath was killed by the other males when the group split.

In 1964 a male named Mike used wits over strength to rise to the top.

JG Mike with his kerosene cans.

DQ Mike had found a new way to be an alpha, right?

JG Mmm.

DQ Tell me about that.

JG Well, he was highly motivated. That was something else I wasn't allowed to talk about.

DQ Motivation.

JG He was motivated to rise up the hierarchy. But there were 11 other males all ranking higher than him at the beginning. And he'd lost two of his canines. He wasn't a spring chicken. He was, I suppose, a bit older than David. Anyway, he picked up and used as a prop one of these empty tin cans, four-gallon cans, and he found it made wonderful noise. And the chimps whom he was displaying towards ran out of his way. Mike just somehow realized that he could take advantage of this. He learned to keep three of them [empty kerosene cans] ahead of him, kicking and hitting them. I remember this one group—five males, including top-ranking Goliath—and normally Mike was very afraid of all of them. But with these three cans, he charged straight toward them and they all ran away. And then he sat [she makes a panting noise], and they all came and groomed him.

DQ And that was the beginning of his being the alpha.

David Quammen wrote about bonobos in the March 2013 issue. Photographers Anup Shah and Fiona Rogers's book, Tales From Gombe, *will be published in October.*

JG Yes. It took him only about four months to get to the top.

I show her an old photo of herself in those early years, with a notebook, one chimp clutching her right hand with both of his.

JG There's our most intelligent chimp ever, right there. Figan.

DQ In what ways did that show?

JG It showed in so many ways.

She tells an elaborate story of Figan learning to unlatch the box in which she kept bananas. Figan and his companion Evered both learned the trick, but only Figan understood that doing it in the presence of more dominant males meant the immediate surrender of those bananas.

JG I watched him. He just sits there looking around casually, and…he's got a foot on the handle; there's males all around. He sits there—once it was for over half an hour—until the males left. Then he went and got the bananas.

Next we look at the big photo spread of Frodo.

JG He was a bully. He was a real bully. I mean, OK, he bullied me. Bullied a lot of people, but even as a child, he bullied the other young ones. Very often, if two were playing, if they saw Frodo come along, they stopped playing. Because they knew as soon as he joined in, he'd hurt one of them.

In adulthood Frodo deposed his own brother as alpha male, threw his weight around, and sometimes showed aggression toward humans but also restraint—as Jane herself and a videographer named Bill Wallauer had occasion to see.

JG We both knew that Frodo was not trying to kill us or really hurt us. He was just trying to demonstrate his strength. I kept saying, "Frodo, I know you're dominant. I mean, you don't have to prove it. I'm just a weak female," you know. "Please." Three times with me and twice with Bill, if he'd done what he normally does, which is push you, we would have died. Because of the slope and the rocks below. And he didn't do it.

DQ He stopped short.

JG Yeah, he stopped short. And he did have a very sweet side with infants. To watch him playing with the young infants was charming.

So Frodo was complicated. But so were they

all. I pull out, like another tarot card, an image of Gremlin.

JG She's been my favorite chimp for ages. She's such a good mother. And you know, she tried so hard to help her mother, Melissa, when Melissa had twins.

Twins are rare among chimps, and very difficult for a mother to nurture. Melissa lost one of her pair. Gremlin herself later raised two, a signal feat. Then, while her next offspring was still unweaned, Gremlin commandeered an infant from her own firstborn daughter, Gaia.

JG So weird. So much we still don't understand. It was almost as though, having had two babies, she was used to having two babies. And she had a two-and-a-half-year-old and, well, that wasn't really quite enough. So she better have another. And it was awful. She nursed him, suckled him, did everything she should. She treated him beautifully.

But there wasn't enough milk in Gremlin for two youngsters. Gaia's infant languished in his grandmother's care and died.

DQ Tell me about Sparrow.

JG A survivor. She's just another of the great matriarchs, with all these children.

DQ Is she still alive?

JG Yeah. It's amazing.

Sparrow is the mother of seven; she's grandmother or great-grandmother to several more. During the course of Jane's 54-year association with Gombe, as a researcher and then a protector and advocate, there have been many more joyous moments than sorrowful ones, but in the fullness of time all good things end, as Sparrow's life will too. David Greybeard and Goliath and Mike are long gone, Frodo more recently. Near the close of our chat, Jane recollected the death of Flo, mother of at least five, grandmother of many, the greatest and most beloved matriarch ever at Gombe.

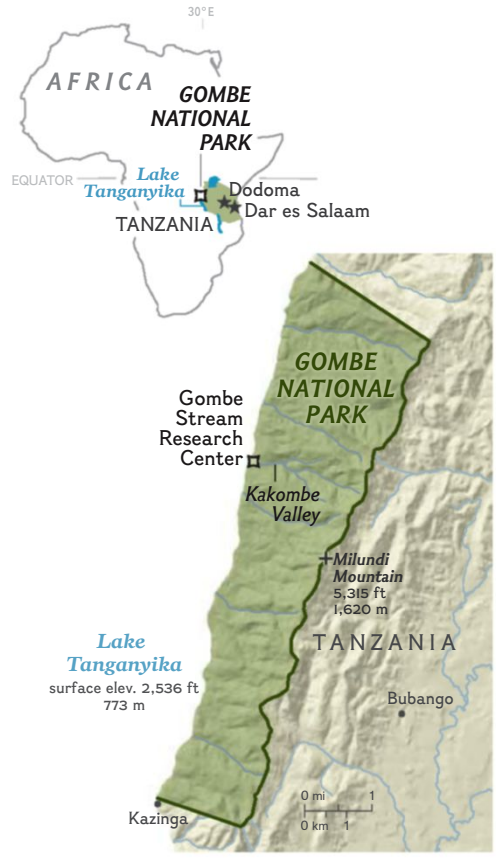
DQ How did Flo die?

JG Crossing a stream. Very old. And she was with Flint. That was when Flint was eight but still so dependent on her. Did I cry? Yes.

DQ Did you find her?

JG I wasn't the one who actually found her, but I saw her. And I watched—the saddest thing—I watched Flint by the body. Couldn't understand it. Kept pulling at her hand, like he did when she was alive. Like, "Please groom me, Mum." At one point he left her and went to a tree where they had slept together about two nights before. He climbed up very, very, very slowly, and he went slowly along the branch and came to this nest, and he stood looking at it, and he turned around and came back. It was so moving.

Flint died about three weeks later, an orphan eight-year-old, mourning his mother and mourned by Dr. Goodall, the ethologist who recognized that chimpanzees have personality and experience emotion. ☐



To see more of these chimps, tune in to *Kingdom of the Apes* July 24 on Nat Geo WILD. Check local listings.

NGM STAFF; INTERNATIONAL MAPPING
SOURCES: LILIAN PINTEA, JANE GOODALL INSTITUTE



Samwise

13-year-old female

SIRED BY FRODO, DAUGHTER OF SANDI

Named, like several Gombe chimps, for a J. R. R. Tolkien character, Samwise is entering adulthood, a fraught period for female chimps. Still close to her mother, Samwise will soon attract the interest of males. Most female chimpanzees leave their birth community to avoid breeding with close relatives, but many in the Kasekela community have chosen to stay. Researchers can't predict whether Samwise will go. "Since Samwise is related to most adult males in her group," says Kara Schroepfer Walker, who studies adolescent females, "if she's smart, she'll make the leap."



Gaia

21-year-old female

DAUGHTER OF GREMLIN, MOTHER OF GOOGLE

"An incredibly caring, nurturing, big-sister type," is how researcher Elizabeth Lonsdorf describes Gaia. She is credited with helping raise her younger twin sisters, Golden and Glitter. Gaia focused on Glitter, carrying, grooming, and looking after her, while her mother, Gremlin, attended to Golden. In 2009 Gaia gave birth to and successfully kept baby Google, whom she fiercely defends after having had three previous infants stolen; all died. Gaia is also one of the most prodigious termite fishers at Gombe, often spending hours at a time collecting this treat with a well-chosen stick.



Sparrow

56-year-old female *(second from right, looking up)*

WITH CHILDREN AND GRANDCHILDREN



Oldest chimp in Gombe and undisputed matriarch of the S family, Sparrow and two generations of offspring enjoy a tight-knit grooming session. “Sparrow is a tough old bird,” observes Carson Murray, who followed her for several seasons. “She raises strong, competent daughters,” Murray says, “but her sons are mama’s boys.”



Gremlin

44-year-old female

MOTHER OF GIZMO, GAIA, GLITTER, GOLDEN, AND GIMLI

Followed by researchers since birth, Gremlin both awes and puzzles her observers. A favorite of Goodall's, Gremlin has raised twins Golden and Glitter, now 16, the first known wild-born chimp duo to reach adulthood. "Baby chimps are a handful," says Elizabeth Lonsdorf, who studies infant development. "Gremlin showed incredible strength and patience with them." Gremlin is also a baby thief. She snatched three newborns from her daughter Gaia. "This is a riddle," Lonsdorf says. "Something incites in her an extreme protectiveness of babies." Past her prime, Gremlin is still the glue of the large G family.



Gizmo

5-year-old male

SON OF GREMLIN, BROTHER OF GAIA

His name suits him: Gizmo, two at the time of this photograph, is a small and playful kid, usually found buzzing around his older brother and sisters, looking for a hug or a tumble. Only recently has his mother, Gremlin, quit carrying him on her back during long-distance travel. Forced to become independent at just two years, when Gremlin started to nurse a granddaughter, Gizmo has grown up needy for attention. He can reliably be found in Gombe's central Kakombe Valley, sporting or grooming in the midst of a G family gathering. "It's hard to imagine," Carson Murray observes, "that Gizmo could ever become an alpha male."



Nasa

26-year-old female

PARENTS UNKNOWN, NO OFFSPRING



Nasa showed up in 2000, probably an emigrant from a community to the south. Her name comes from the Swahili word meaning “to grasp,” reflecting an outsider female’s need to fit in. She is a good hunter, big enough to fend off males vying for her catch. Typical of females without offspring, Nasa ranges widely in her protected realm.

The Future of FOOD natgeofood.com

By 2050 we'll need to feed two billion more people. This special eight-month series explores how we can do that—without overwhelming the planet.

Why are people malnourished in the richest country on Earth?

Millions of working Americans don't know where their next meal is coming from.

The New Face of Hunger

By *Tracie McMillan*

Photographs by *Kitra Cahana, Stephanie Sinclair,* and *Amy Toensing*



Kristin Hahn and her grandmother, Janet Groven, visit a weekly soup kitchen in Charles City, Iowa. “By the end of the month we have nothing,” says Groven, who also depends on a food pantry to feed her family. Of America’s 48 million “food insecure”—the modern term for the hungry—more than half are white, and more than half live outside cities.

AMY TOENSING





New York City's Bronx borough is crammed with fast-food restaurants but has few grocery stores, earning it a reputation as a food desert. Home to America's poorest congressional district, the Bronx has a hunger rate of 37 percent, the highest in the city.

STEPHANIE SINCLAIR


BEAUT
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FOOD

On a gold-gray morning in Mitchell County, Iowa, Christina Dreier sends her son, Keagan, to school without breakfast. He is three years old, barrel-chested, and stubborn, and usually refuses to eat the free meal he qualifies for at preschool. Faced with a dwindling pantry, Dreier has decided to try some tough love: If she sends Keagan to school hungry, maybe he'll eat the free breakfast, which will leave more food at home for lunch.

Dreier knows her gambit might backfire, and it does. Keagan ignores the school breakfast on offer and is so hungry by lunchtime that Dreier picks through the dregs of her freezer in hopes of filling him and his little sister up. She shakes the last seven chicken nuggets onto a battered baking sheet, adds the remnants of a bag of Tater Tots and a couple of hot dogs from the fridge, and slides it all into the oven. She's gone through most of the food she got last week from a local food pantry; her own lunch will be the bits of potato left on the kids' plates. "I eat lunch if there's enough," she says. "But the kids are the most important. They have to eat first."

The fear of being unable to feed her children hangs over Dreier's days. She and her husband, Jim, pit one bill against the next—the phone against the rent against the heat against the gas—trying always to set aside money to make up for what they can't get from the food pantry or with their food stamps, issued by the Supplemental Nutrition Assistance Program (SNAP). Congressional cuts to SNAP last fall of five billion dollars pared her benefits from $205 to $172 a month.

On this particular afternoon Dreier is worried about the family van, which is on the brink of repossession. She and Jim need to open a new bank account so they can make automatic payments instead of scrambling to pay in cash. But that will happen only if Jim finishes work early. It's peak harvest time, and he often works until eight at night, applying pesticides on commercial farms for $14 an hour. Running the errand would mean forgoing overtime pay that could go for groceries.

It's the same every month, Dreier says. Bills go unpaid because, when push comes to shove, food wins out. "We have to eat, you know," she says, only the slightest hint of resignation in her voice. "We can't starve."

CHANCES ARE GOOD that if you picture what hunger looks like, you don't summon an image of



Learn more about the Dreier family and their struggles on our digital editions.

Keagan and Cheyenne Dreier have the toys and trappings of a middle-class life, but their parents rely on donated foods—typically processed—to feed them. "It's not like we can eat all healthy," says mom Christina. With junk food plentiful and often cheap, hunger and obesity are now parallel problems.

someone like Christina Dreier: white, married, clothed, and housed, even a bit overweight. The image of hunger in America today differs markedly from Depression-era images of the gaunt-faced unemployed scavenging for food on urban streets. "This is not your grandmother's hunger," says Janet Poppendieck, a sociologist at the City University of New York. "Today more working people and their families are hungry because wages have declined."

In the United States more than half of hungry households are white, and two-thirds of those with children have at least one working adult—typically in a full-time job. With this new image comes a new lexicon: In 2006 the U.S. government replaced "hunger" with the term "food insecure" to describe any household where, sometime during the previous year, people didn't have enough food to eat. By whatever name, the number of people going hungry has grown dramatically in the U.S., increasing to 48 million by 2012—a fivefold jump since the late 1960s, including an increase of 57 percent since the late 1990s. Privately run programs like food pantries and soup kitchens have mushroomed too. In 1980 there were a few hundred emergency food programs across the country; today there are 50,000. Finding food has become a central worry for millions of Americans. One in six reports running out of food at least once a year. In many European countries, by contrast, the number is closer to one in 20.

To witness hunger in America today is to enter a twilight zone where refrigerators are so frequently bare of all but mustard and ketchup that it provokes no remark, inspires no

AMY TOENSING



Mikka Drahein, four, snacks on pasta at her home in Osage, Iowa. A grain elevator next door stores some of the state's vast output of corn and soybeans. Government nutrition guidelines encourage eating fruits and vegetables, but subsidies support mostly the production of corn, soy, and other commodity crops.

AMY TOENSING







Dinner can be a haphazard affair for the White family. Parents Rebecca and Bob struggle to feed five children—and pay all their bills—on the $2,000-a-month salary Bob earns at the nearby Winnebago plant. Nearly 60 percent of food-insecure U.S. households have at least one working family member.

AMY TOENSING

embarrassment. Here dinners are cooked using macaroni-and-cheese mixes and other processed ingredients from food pantries, and fresh fruits and vegetables are eaten only in the first days after the SNAP payment arrives. Here you'll meet hungry farmhands and retired schoolteachers, hungry families who are in the U.S. without papers and hungry families whose histories stretch back to the *Mayflower.* Here pocketing food from work and skipping meals to make food stretch are so common that such practices barely register as a way of coping with hunger and are simply a way of life.

It can be tempting to ask families receiving food assistance, If you're really hungry, then how can you be—as many of them are—overweight? The answer is "this paradox that hunger and obesity are two sides of the same coin," says Melissa Boteach, vice president of the Poverty and Prosperity Program of the Center for American Progress, "people making trade-offs between food that's filling but not nutritious and may actually contribute to obesity." For many of the hungry in America, the extra pounds that result from a poor diet are collateral damage—an unintended side effect of hunger itself.

It can be tempting to ask families receiving food assistance, If you're really hungry, then how can you be overweight? For many of the hungry in America, it's an unintended side effect of hunger itself.

AS THE FACE OF HUNGER has changed, so has its address. The town of Spring, Texas, is where ranchland meets Houston's sprawl, a suburb of curving streets and shade trees and privacy fences. The suburbs are the home of the American dream, but they are also a place where poverty is on the rise. As urban housing has gotten more expensive, the working poor have been pushed out. Today hunger in the suburbs is growing faster than in cities, having more than doubled since 2007.

Yet in the suburbs America's hungry don't look the part either. They drive cars, which are a necessity, not a luxury, here. Cheap clothes and toys can be found at yard sales and thrift shops, making a middle-class appearance affordable. Consumer electronics can be bought on installment plans, so the hungry rarely lack phones or televisions. Of all the suburbs in the country, northwest Houston is one of the best places to see how people live on what might be called a minimum-wage diet: It has one of the highest percentages of households receiving SNAP assistance where at least one family member holds down a job. The Jefferson sisters, Meme and Kai, live here in a four-bedroom, two-car-garage, two-bath home with Kai's boyfriend, Frank, and an extended family that includes their invalid mother, their five sons, a daughter-in-law, and five grandchildren. The house has a rickety desktop computer in the living room and a television in most rooms, but only two actual beds; nearly everyone sleeps on mattresses or piles of blankets spread out on the floor.

Though all three adults work full-time, their income is not enough to keep the family consistently fed without assistance. The root problem is the lack of jobs that pay wages a family can live on, so food assistance has become the government's—and society's—way to supplement low wages. The Jeffersons receive $125 in food stamps each month, and a charity brings in meals for their bedridden matriarch.

Like most of the new American hungry, the Jeffersons face not a total absence of food but the gnawing fear that the next meal can't be counted on. When Meme shows me the family's food supply, the refrigerator holds takeout boxes and beverages but little fresh food. Two cupboards are stocked with a smattering of canned beans and sauces. A pair of freezers in the garage each contain a single layer of food, enough to fill bellies for just a few days. Meme says she took the children aside a few months earlier to tell them they were eating too much and wasting food besides. "I told them if they keep wasting, we have to go live on the corner, beg for money, or something."

Jacqueline Christian is another Houston mother who has a full-time job, drives a comfortable sedan, and wears flattering clothes. Her older son, 15-year-old Ja'Zarrian, sports bright orange Air Jordans. There's little clue to the family's hardship until you learn that their clothes come mostly from discount stores, that Ja'Zarrian mowed lawns for a summer to get the sneakers, that they're living in a homeless shelter, and that despite receiving $325 in monthly food stamps, Christian worries about not having enough food "about half of the year."

Christian works as a home health aide, earning $7.75 an hour at a job that requires her to crisscross Houston's sprawl to see her clients. Her schedule, as much as her wages, influences what she eats. To save time she often relies on premade food from grocery stores. "You can't go all the way home and cook," she says.

On a day that includes running a dozen errands and charming her payday loan officer into giving her an extra day, Christian picks up Ja'Zarrian and her seven-year-old, Jerimiah, after school. As the sun drops in the sky, Jerimiah begins complaining that he's hungry. The neon glow of a Hartz Chicken Buffet appears up the road, and he starts in: Can't we just get some gizzards, please?

Christian pulls into the drive-through and orders a combo of fried gizzards and okra for $8.11. It takes three declined credit cards and an emergency loan from her mother, who lives nearby, before she can pay for it. When the food finally arrives, filling the car with the smell of hot grease, there's a collective sense of relief. On the drive back to the shelter the boys eat until the gizzards are gone, and then drift off to sleep.

Christian says she knows she can't afford to eat out and that fast food isn't a healthy meal. But she'd felt too stressed—by time, by Jerimiah's insistence, by how little money she has—not to give in. "Maybe I can't justify that to someone who wasn't here to see, you know?" she says. "But I couldn't let them down and not get the food."

OF COURSE IT IS POSSIBLE to eat well cheaply in America, but it takes resources and know-how that many low-income Americans don't have. Kyera Reams of Osage, Iowa, puts an incredible amount of energy into feeding her family of six a healthy diet, with the help of staples from food banks and $650 in monthly SNAP benefits. A stay-at-home mom with a high school education, Reams has taught herself how to can fresh produce and forage for wild ginger and cranberries. When she learned that SNAP benefits could be used to buy vegetable plants, she dug two gardens in her yard. She has learned about wild mushrooms so she can safely pick ones that aren't poisonous and has lobbied the local library to stock field guides to edible wild plants.

"We wouldn't eat healthy at all if we lived off the food-bank food," Reams says. Many foods commonly donated to—or bought by—food pantries are high in salt, sugar, and fat. She estimates her family could live for three months on the nutritious foods she's saved up. The Reamses have food security, in other words, because Kyera makes procuring food her full-time job, along with caring for her husband, whose disability payments provide their only income.

But most of the working poor don't have the time or know-how required to eat well on little. Often working multiple jobs and night shifts,

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Tracie McMillan is the author of The American Way of Eating. *Photographers Kitra Cahana, Stephanie Sinclair, and Amy Toensing are known for their intimate, sensitive portraits of people.*



Two boxes of fried chicken are devoured within minutes after a neighbor drops by the Bronx apartment of Hullamatou Ceesay to share lunch with a crew of cousins. Most of America's hungry are native-born, but new immigrants like this family from Gambia struggle too, taking meals wherever they can find them.

STEPHANIE SINCLAIR







A young father braves the highways of sprawling Spring, Texas, north of Houston, to reach a homeless shelter and a free meal. The suburbs have become a new home for the hungry. The rates of poverty and of food stamp use are so high that advocates and legislators coined the phrase “the SUV poor.”

KITRA CAHANA

they tend to eat on the run. Healthful food can be hard to find in so-called food deserts—communities with few or no full-service groceries. Jackie Christian didn't resort to feeding her sons fried gizzards because it was affordable but because it was easy. Given the dramatic increase in cheap fast foods and processed foods, when the hungry have money to eat, they often go for what's convenient, just as better-off families do.

IT'S A CRUEL IRONY that people in rural Iowa can be malnourished amid forests of cornstalks running to the horizon. Iowa dirt is some of the richest in the nation, even bringing out the poet in agronomists, who describe it as "black gold." In 2007 Iowa's fields produced roughly one-sixth of all corn and soybeans grown in the U.S., churning out billions of bushels.

These are the very crops that end up on Christina Dreier's kitchen table in the form of hot dogs made of corn-raised beef, Mountain Dew sweetened with corn syrup, and chicken nuggets fried in soybean oil. They're also the foods that the U.S. government supports the most. In 2012 it spent roughly $11 billion to subsidize and insure commodity crops like corn and soy, with Iowa among the states receiving the highest subsidies. The government spends much less to bolster the production of the fruits and vegetables its own nutrition guidelines say should make up half the food on our plates. In 2011 it spent only $1.6 billion to subsidize and insure "specialty crops"—the bureaucratic term for fruits and vegetables.

Those priorities are reflected at the grocery store, where the price of fresh food has risen steadily while the cost of sugary treats like soda has dropped. Since the early 1980s the real cost of fruits and vegetables has increased by 24 percent. Meanwhile the cost of nonalcoholic beverages—primarily sodas, most sweetened with corn syrup—has dropped by 27 percent.

"We've created a system that's geared toward keeping overall food prices low but does little to support healthy, high-quality food," says global food expert Raj Patel. "The problem can't be fixed by merely telling people to eat their fruits and vegetables, because at heart this is a problem about wages, about poverty."

When Christina Dreier's cupboards start to get bare, she tries to persuade her kids to skip snack time. "But sometimes they eat saltine crackers, because we get that from the food bank," she said, sighing. "It ain't healthy for them, but I'm not going to tell them they can't eat if they're hungry."

The Dreiers have not given up on trying to eat well. Like the Reamses, they've sown patches of vegetables and a stretch of sweet corn in the large green yard carved out of the cornfields behind their house. But when the garden is done for the year, Christina fights a battle every time she goes to the supermarket or the food bank. In both places healthy foods are nearly out of reach. When the food stamps come in, she splurges on her monthly supply of produce, including a bag of organic grapes and a bag of apples. "They love fruit," she says with obvious pride. But most of her food dollars go to the meat, eggs, and milk that the food bank doesn't provide; with noodles and sauce from the food pantry, a spaghetti dinner costs her only the $3.88 required to buy hamburger for the sauce.

What she has, Christina says, is a kitchen with nearly enough food most of the time. It's just those dicey moments, after a new bill arrives or she needs gas to drive the kids to town, that make it hard. "We're not starved around here," she says one morning as she mixes up powdered milk for her daughter. "But some days, we do go a little hungry." □

The Future of Food

COMING IN SEPTEMBER

Research on the evolution of diet raises the question…

Could eating like our ancestors make us healthier?

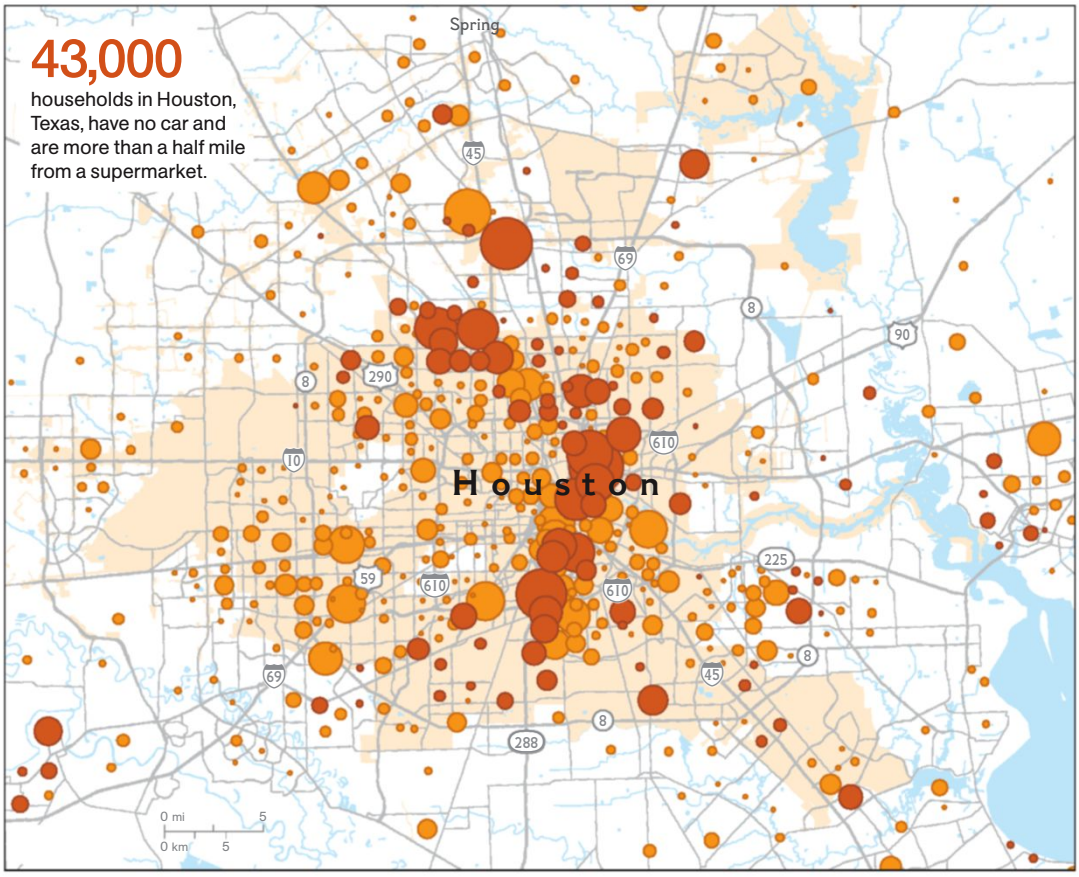
ON THE WEB

Join the conversation at *natgeofood.com* and get daily food news, videos, informed blogs, interactive graphics, bonus photos, and food facts of the day.

The magazine thanks The Rockefeller Foundation and members of the National Geographic Society for their generous support of this series of articles.

Hunger in America

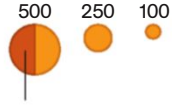
Looking for a Decent Meal



Stranded in a Food Desert

Tens of thousands of people in Houston and in other parts of the U.S. live in what's called a food desert: Their homes are more than half a mile from a supermarket, and they don't own a car, because of poverty, illness, or age. Public transportation may not fill the gap. How do they get nutritious food? Small neighborhood markets or fast-food restaurants may be within walking distance but may not accept food vouchers. And if they do, they may charge more and offer fewer nutritious options than supermarkets.

Households lacking a car and located more than half a mile from a supermarket



Dark orange: Households in neighborhoods with the greatest poverty

City of Houston

VIRGINIA W. MASON AND JASON TREAT, NGM STAFF
SOURCES: USDA; CITY OF HOUSTON; U.S. CENSUS BUREAU

FOOD

Help for the Hungry

More than 48 million Americans rely on what used to be called food stamps, now SNAP: the Supplemental Nutrition Assistance Program. In 2013 benefits totaled $75 billion, but payments to most households dropped; the average monthly benefit was $133.07 a person, less than $1.50 a meal. SNAP recipients typically run through their monthly allotment in three weeks, then turn to food pantries. Who qualifies for SNAP? Households with gross incomes no more than 130 percent of the poverty rate. For a family of four that qualifying point is $31,005 a year.*

*QUALIFYING INCOMES IN ALASKA AND HAWAII ARE HIGHER THAN IN THE CONTIGUOUS U.S.

17.6 million
households in the U.S. don't have adequate resources to meet their basic food needs.

72%
of SNAP recipients are children, disabled adults, or the elderly.

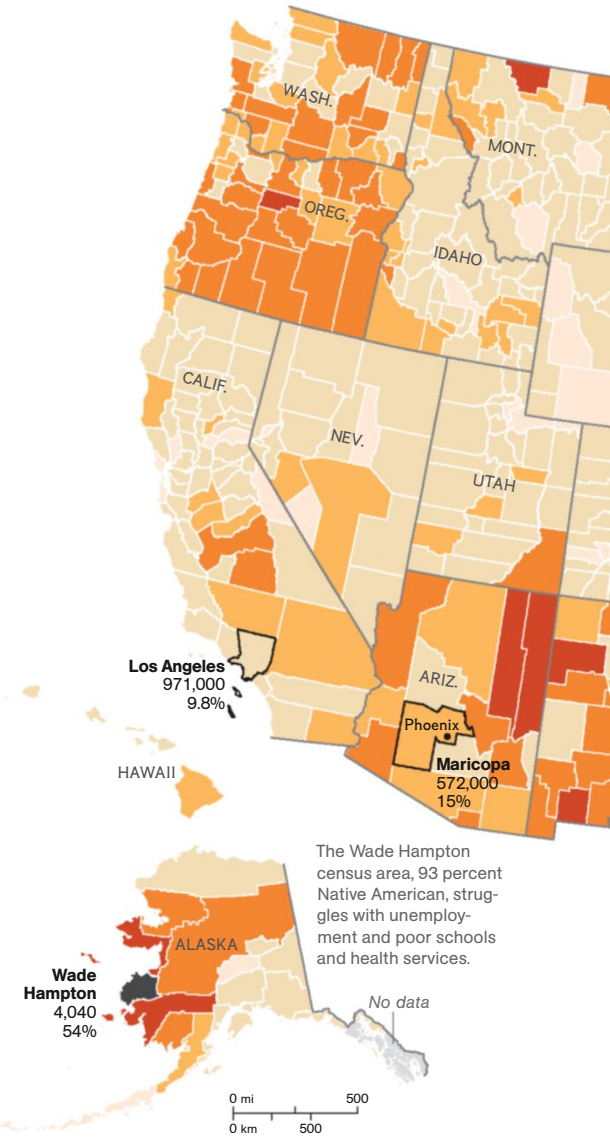
Counties with the highest SNAP participation in 2010

Recipients, in thousands

1	Los Angeles, CA	971
2	Cook, IL	902
3	Kings, NY	689
4	Harris, TX	587
5	Maricopa, AZ	572

Percent of county population

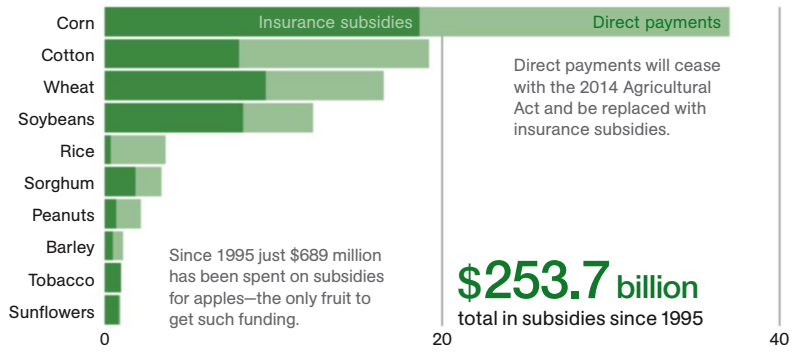
1	Shannon, SD	59
2	Todd, SD	55
3	Wade Hampton, AK	54
4	Owsley, KY	52
5	Humphreys, MS	51

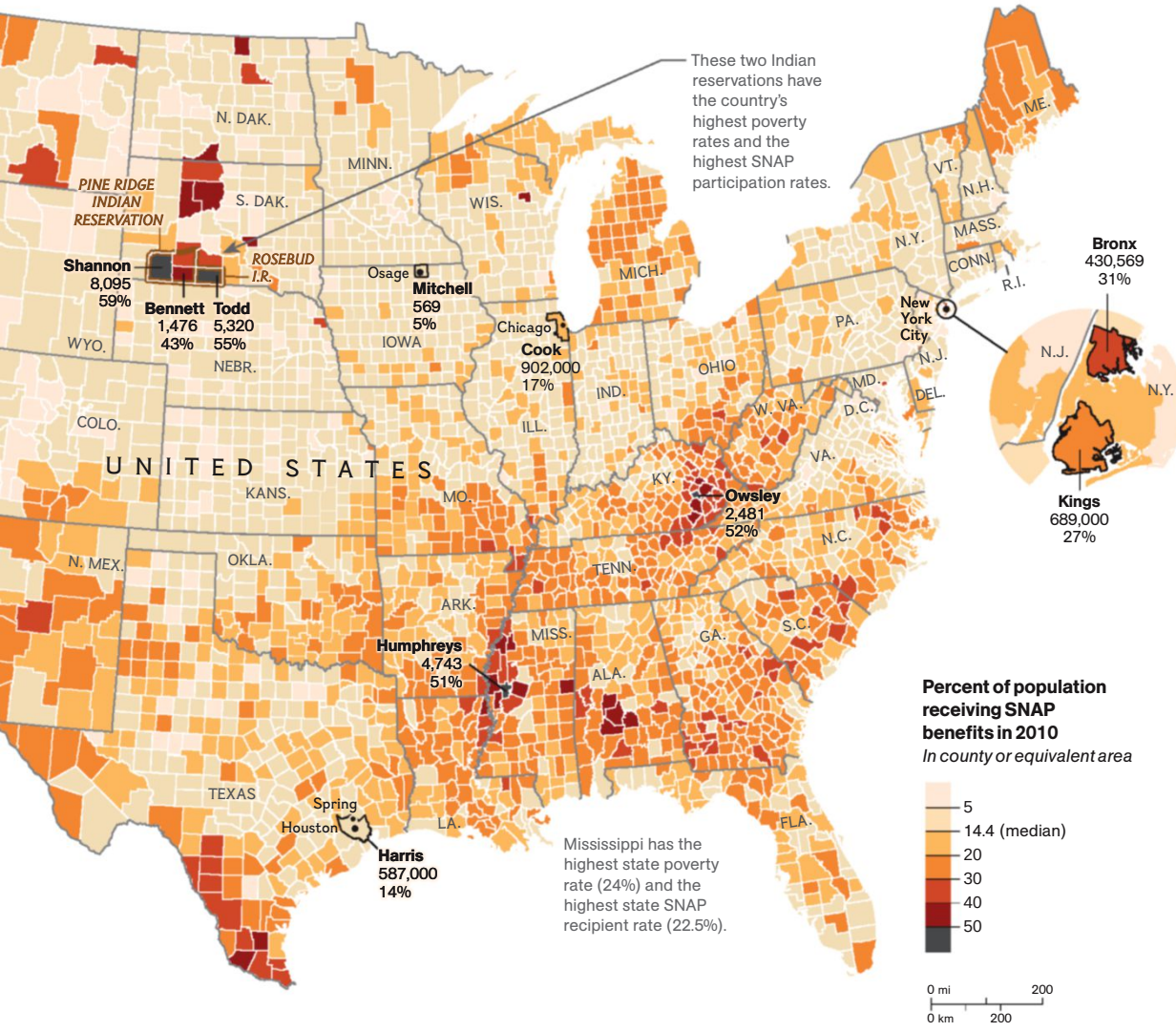


Crops taxpayers support with subsidies

Federal crop subsidies began in the 1920s, when a quarter of the U.S. population worked on farms. The funds were meant to buffer losses from fluctuating harvests and natural disasters. Today most subsidies go to a few staple crops, produced mainly by large agricultural companies and cooperatives.

Top ten farm subsidies by crop
1995–2012, in billions of dollars

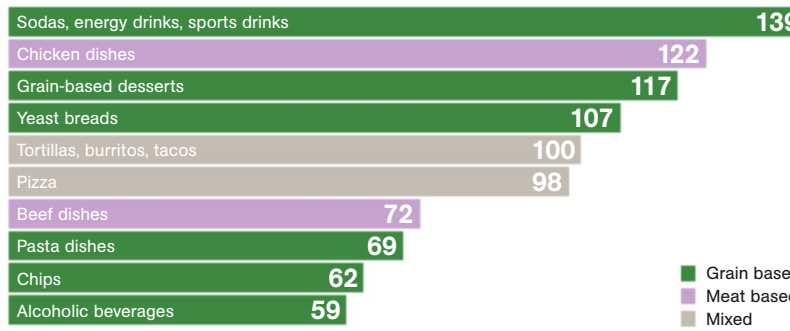




How subsidized crops affect diet

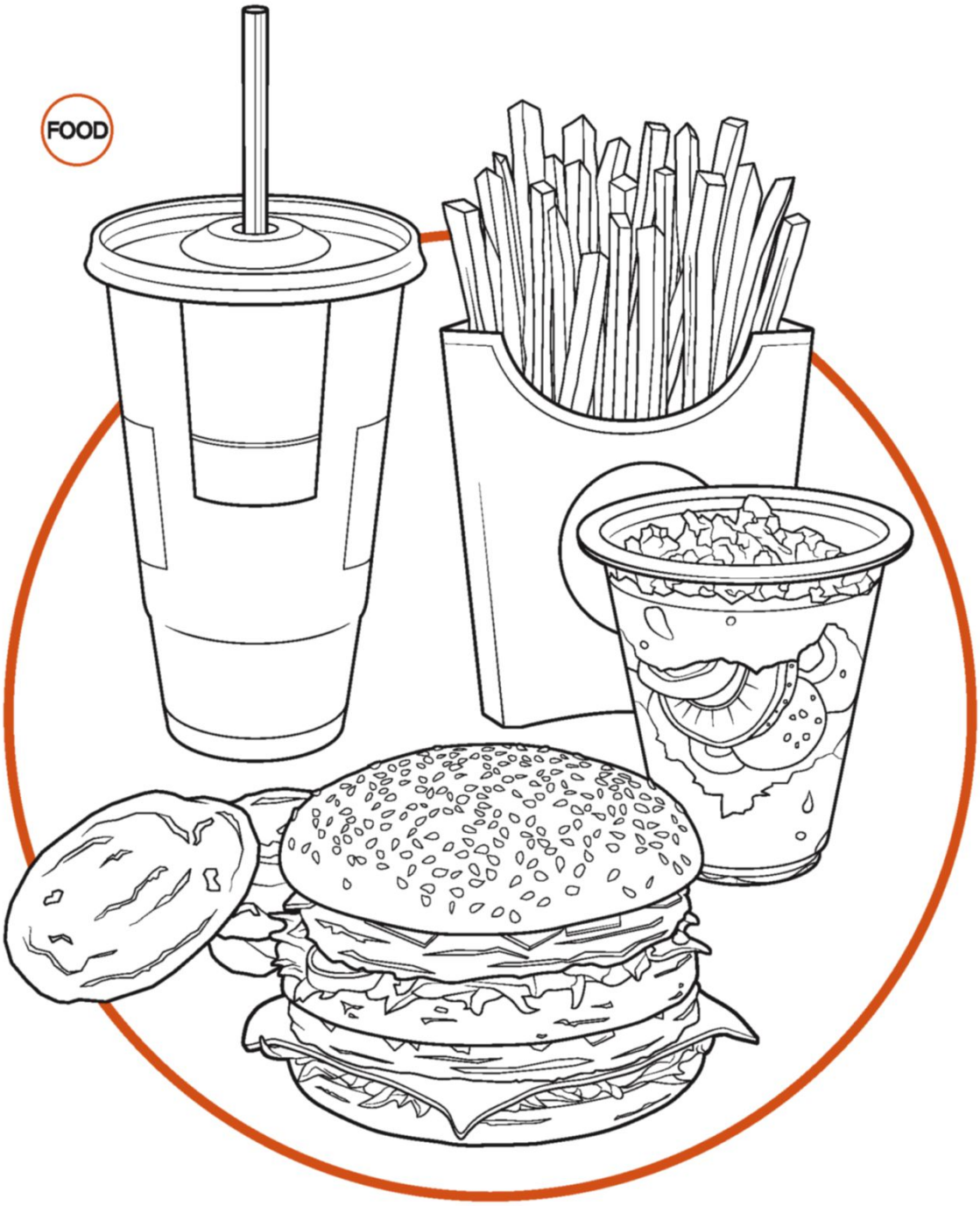
Subsidized corn is used for biofuel, corn syrup, and, mixed with soybeans, chicken feed. Subsidies reduce crop prices but also support the abundance of processed foods, which are more affordable but less nutritious. Across income brackets, processed foods make up a large part of the American diet.

Top ten sources of calories for low-income invdividuals
Age two and older, per person per day



VIRGINIA W. MASON AND JASON TREAT, NGM STAFF; AMANDA HOBBS

SOURCES: USDA; FOOD RESEARCH AND ACTION CENTER; CENTER ON BUDGET AND POLICY PRIORITIES; MISSISSIPPI DEPARTMENT OF HUMAN SERVICES; ENVIRONMENTAL WORKING GROUP; NATIONAL CANCER INSTITUTE



What's for Dinner?

You've got hunger pangs, an empty refrigerator, and ten dollars. What kind of food will you buy, fast food or ingredients for a home-cooked meal? Time, not nutrition, is often the deciding factor. "Cooking at home requires planning ahead," says Jessica Todd, an economist with the USDA. According to her research,

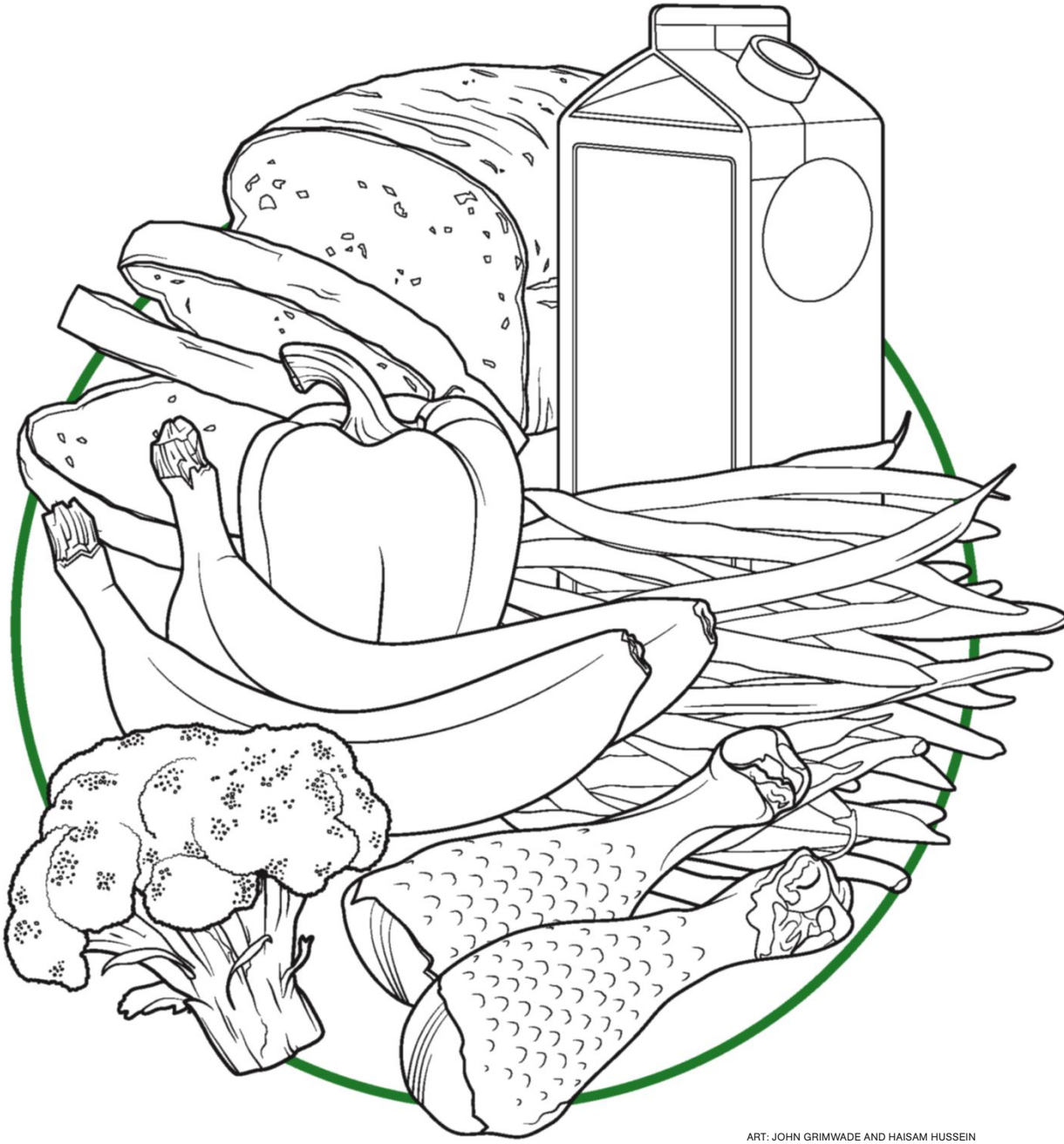
$10

Spent on fast food

Typical McDonald's menu

Big Mac sandwich	$3.99
Large french fries	2.40
Fruit 'N Yogurt Parfait	1.00
Three cookies	1.00
Large soft drink	1.49
Total	**$9.88**

McDonald's is the largest hamburger fast-food chain in the world, serving food in about 119 countries.



ART: JOHN GRIMWADE AND HAISAM HUSSEIN

people ate out less often during the recession. One likely reason: more time at home to cook. A Bureau of Labor Statistics study shows that the time difference can be significant: 128 minutes for grocery shopping, food preparation, and cleanup versus 34 minutes, including travel time, for the aptly named fast food.

$10

Spent on market produce

Typical market produce prices in Washington, D.C.

Half gallon of milk	$1.99
Half pound green beans	1.35
One loaf wheat bread	2.49
Bell pepper	1.19
Two bananas	0.40
Two chicken drumsticks	1.71
Crown broccoli	0.80
Total	**$9.93**



FRANZ JOSEF LAND
THE MEANING OF NORTH



A polar bear stands sentinel on Rudolf Island in Russia's Franz Josef Land archipelago, destination of a multidisciplinary scientific expedition in the summer of 2013.





Walruses approach an expedition boat from a haul out on Hooker Island. During summer, when sea ice diminishes, walruses congregate on shorelines, where food is scarce and youngsters can get trampled.





The steep face of Rubini Rock, a promontory of Hooker Island, supports thousands of nesting pairs of seabirds. Kittiwakes, little auks, glaucous gulls, Brünnich's guillemots, and fulmars arrive here in summer to breed.



The wreckage of an Ilyushin-14T cargo plane testifies to hard times on Hayes Island, where an old Soviet weather-research outpost called Krenkel Station once harbored hundreds. A tiny crew staffs it now.



BY DAVID QUAMMEN
PHOTOGRAPHS BY CORY RICHARDS

Feodor Romanenko raises his arms. "Dear colleagues," he says, with his usual puckish smile, and then launches into his Russian-accented French. "Dear colleagues" aren't quite the only words of English he knows, but they're clearly his favorites, useful for summoning attention from a motley international group such as ours. Dear colleagues, I propose that we now climb up there, he says, indicating a precipitous, unstable, ugly hillside of scree. Dear colleagues, lunchtime! Let us enjoy it here atop the butte before high winds and the next snowstorm arrive. Dear colleagues, he brags cheerily to our evening assembly, today my group made five wondrous discoveries, including two kinds of basalt! and some Mesozoic sediments! and evidence of recent deglaciation! Romanenko is a geomorphologist based at Moscow State University, and after 28 seasons on the shores and the islands of the Arctic Ocean, his enthusiasm for his work is still boyish. Trudging across a severe northern landscape, he exudes contagious joy in the doing of field science—of making close observations, seeing patterns, compiling data that may help answer, among other mysteries, the question of ice.

We have come north with Romanenko into the high Russian Arctic, to an archipelago known as Franz Josef Land, and although it's not our primary purpose, that question underlies much of what we're here to learn. It's really three questions: Why is the perennial ice melting? How far will that melting go? And with what ecological consequences? When you make a biological expedition into the high polar regions, Arctic or Antarctic, in this era of climate change, the question of ice is always important, whether you address it directly or indirectly.

Our approach is indirect. We have come north out of Murmansk across the Barents Sea, almost 40 of us, members of the 2013 Pristine Seas Expedition to Franz Josef Land, to view this remote archipelago through a variety of lenses—botany, microbiology, ichthyology, ornithology, and more. Franz Josef Land comprises 192 islands, most of them built of Mesozoic sediments covered with a capping of columnar basalt, and so flat across the top that, viewed without ice (as they increasingly are), they look like mesas or buttes in Arizona. Throughout earlier times they supported no permanent human habitation—until the Soviets established research stations and military bases on a few of

David Quammen's last story from Russia, in August 2009, was about salmon on the remote Kamchatka Peninsula. Cory Richards's latest story, "Digging Utah's Dinosaurs," appeared in the May issue.

Daria Martynova, of the Russian Academy of Sciences, samples the water column to monitor the diversity of copepods—tiny crustaceans crucial to the food webs of the Arctic Ocean.



the islands. That presence diminished to a tiny remnant during the 1990s, but now increased thawing, new sea routes, and economic considerations are bringing renewed attention to this area by the Russian government.

For a month we zigzag through the archipelago, drawn here and there by opportunity and driven by weather, escaping the winds that push the brash ice and the bergs, going ashore when the polar bears let us, admiring the walruses and the ivory gulls and the bowhead whales, gathering data in places where few data have ever been gathered.

We are 800 nautical miles north of the Arctic Circle. Our ship is the *Polaris,* a refitted tourist vessel with closets converted to laboratories, microscopes on dining tables, and an entire salon filled with scuba gear, including dry suits to protect our divers from water at 30°F (minus 1°C). The team includes Russians, Americans, Spaniards, Britons, one Australian, and a couple of Frenchmen. Each day some of us go ashore on the latest island near which we've anchored, to walk transects, band birds, count walruses, or collect plants, while others dive the cold water to take inventory of marine microbes, algae, invertebrates, and fish. The walking days are sometimes long, but we're always back at the ship before dark, because dark never comes. The sun doesn't set; it just loops around irresolutely in the northern sky. The dives are short but dauntingly cold, even for a man wearing

Our guard carries a Saiga-12 automatic shotgun with a banana clip. The last thing we want is to bring that into action.

Ninja Turtles underwear beneath his dry suit. Feodor Romanenko's perspective is especially important among the others, not just for science but also for morale, because it combines geology with élan.

Romanenko is not so space-age in style as the divers. In his floppy-eared hat, his iridescent orange vest, and his hip waders, with his shotgun in hand, he looks like an affable duck hunter from a small town in Minnesota. His other key piece of equipment is a garden spade. Katerina Garankina, one of his Ph.D. students from Moscow State University, red haired and field hardy, assists him in the work of drawing geomorphological profiles of the islands. Michael Fay, doing the botany, is a natural on their daily outings ashore because, like Romanenko, he suffers an unquenchable craving to walk. Fay's epic survey hike across the forests of central Africa ("Megatransect," October 2000, and two later stories) was neither the first of his wilderness treks nor the last, and now that he's 58 years old, dividing his time between a cabin in Alaska and a conservation job with the government of Gabon, he's no less restless and impatient for foot travel through wild places. Arctic flora are mostly new to Fay, but on our first afternoon ashore in Franz Josef Land, I watched him identify a dozen flowering plants to at least their genera, each plant just a delicate clump of leaves within the pavement of rocks and mosses, its stems topped by tiny yellow or red flowers.

Now, nine days later on an island called Payer, Fay is down on his hands and knees again, squinting, counting petals and carpels, taking photos. He's got 12 species in his notebook by the time Romanenko and Garankina have measured the old marine terraces sloping up from the beach.

There are old marine terraces on Payer and elsewhere because Franz Josef Land experienced episodes of uplift during the late Pleistocene and recent millennia, totaling, in some parts of the archipelago, more than 300 feet of elevation. The islands, on the far northerly wedge of the Eurasian plate, now ride higher in the water. Those uplifts have been driven by tectonic forces and to some degree by the disappearance of ice. As a glacier melts away, its mass vanishing, its weight dropping, the terrain beneath tends to rebound, like the dent in a sofa cushion after you've gotten up. So the very shape of the landscape, not to mention the shape of the ecosystem it supports, is determined in part by the presence or absence of ice.

Since the beach landing on Payer, I've been doting on Fay's flowers and scribbling notes, until I hear Romanenko call our notice to a polar bear, huge and handsome, silhouetted on a ridgeline to the west. The bear seems oblivious to us, but we know better than to assume. As it walks, its small head surges forward on the rippling muscles of its long neck, suggesting the short-range striking speed of a snake. Our assigned guard, a young man named Denis Mennikov, carries a Saiga-12 automatic shotgun with a banana clip, but the last thing we want is to bring that into action. Disappearing ice is a hardship for the bears too,

one that may force some reckless behavior. Dear colleagues, please be alert.

THE DYNAMIC VARIABILITY of ice is just part of what once made the Arctic, and Franz Josef Land in particular, so problematic yet enticing to explore. Fridtjof Nansen is only the most famous of the many explorers who touched at the archipelago in the course of some bold, miserable polar expedition. Things have gotten easier, not to say easy, since Nansen's desperate bivouac up here through the winter of 1895-96. For the Pristine Seas voyage we have better maps, lesser ambitions, GPS capacity, and a more comfortable boat. We also have a leader blessed with more aplomb than some of the bullheaded chieftains of the old efforts: National Geographic Explorer-in-Residence Enric Sala, a smart marine ecologist who has pulled together this complex international effort, with support from the Society and other sponsors, as the latest in his series of Pristine Seas Expeditions.

Not many years ago Sala was a professor at the Scripps Institution of Oceanography, teaching grad students about food webs and marine conservation but dissatisfied with his contribution to the world. "I saw myself as refining the obituary of nature, with increased precision," he tells me during a conversation aboard the *Polaris.* His distress at the continuing trends of ecosystem degradation and species loss, in marine as well as terrestrial realms, led him out of academia. "I wanted to try to fix the problem," he says. So in 2005 he assembled a SWAT team of scientists, including experts on marine microbes, algae, invertebrates, and fish, and sailed for the northern Line Islands, a remote cluster of coral outcrops in the Pacific about a thousand nautical miles south of Hawaii.

There they dived the reefs and studied them, making at least one important discovery: that predators, notably sharks, accounted for roughly 85 percent of the local biomass. That was topsy-turvy: Conventional ecological wisdom posited roughly a ten-to-one ratio of prey to predators at each level of a food web from bottom to top. Sala's team accordingly called this the inverted biomass pyramid. In the apparent absence of masses of prey, what could possibly sustain those abundant sharks? The answer was that the prey masses weren't really absent; they were produced copiously and continuously, in the form of small fish with high rates of reproduction, growth, sexual maturation, and turnover, and the predators continually cropped them to the point where they were inconspicuous. This is what ecologists call top-down regulation. It's a crucial thing to know about an ecosystem. Four years later, when outgoing President George W. Bush signed a bill establishing the U.S. Pacific Remote Islands Marine National Monument, Sala was in the room, and a mandate for preserving the inverted biomass pyramid was in the law.

With continuing support from the National Geographic Society, Sala took his Pristine Seas model to a series of other remote oceanic ecosystems, all in the tropics, where the waters were warm, fecund, rich with diversity, and clear. Then he turned his attention to the northernmost archipelago in the world, Franz Josef Land.

Franz Josef Land is a *zakaznik,* a nature reserve, administered within Russian Arctic National Park, so Sala established a partnership with the park and with the Russian Geographical Society. He enlisted Maria Gavrilo, an Arctic seabird biologist who serves as the park's deputy director for science, to be co-leader. He rounded up some of the same doughty researchers (including viral ecologist Forest Rohwer, fisheries ecologist Alan Friedlander, algae expert Kike Ballesteros, and Mike Fay) and trusted dive



ANDY MANN

Video TRUE WILDERNESS

Explore Franz Josef Land with the expedition team on our digital editions and at **ngm.com.**



RUSSIA'S FAR NORTH

Franz Josef Land is actually 192 islands—the northernmost archipelago in the world. Its 6,200-plus square miles are virtually uninhabited, glaciated, and encased in sea ice for much of the year. An Austro-Hungarian expedition discovered it in 1873, the Soviet Union claimed it in 1926, and Russia made it a nature reserve called a *zakaznik* in 1994. It's now home to a single meteorological station, but Russia, eager to find oil and gas and to guard sea-lanes, plans to reopen Arctic military bases.

King Oscar Land

ARCTIC
OCEAN

81°N

Arthur I.

NAGURSKOYE
FRONTIER POST
Est. 1950s

Alexandra Land

Lunny
Ice Cap

Cambridge Sound

Geographers' Bay

Brusilov
Ice Cap

George Land

Tumanny
Ice Cap

Peary
Ice Cap

Russky
Ice Cap

Bruce I.

Mabel I.

CAMP EIRA

Bell I.

Cape
Flora

NATIONAL PARK
SEASONAL
BASE

June 17,
1896

Northbrook I.

Franz

De Bruyne Sound

British Channel

Luigi I.

Koettlitz I.

Nansen I.

Nansen,
spring 1896

Pritchett I.

Eaton I.

Rubini Rock

TIKHAYA
"CALM BAY"
NATIONAL
PARK BASE

Hooker I.

Leigh
Smith I.

Barents

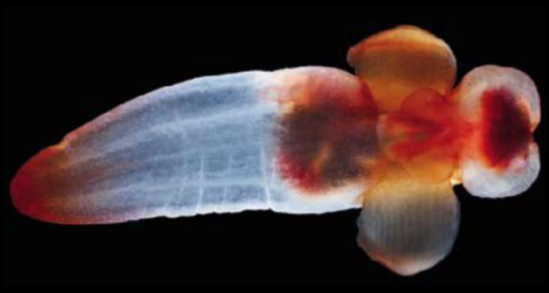

IMAGINARY ISLANDS
Maps made during the 1873 Austro-Hungarian expedition show King Oscar Land (left) and Petermann Land (off map). Both proved to be mirages.
Cape Fligely
Rudolf I.
WEATHER STATION Abandoned 1995
Neumayer Sound
Hohenlohe I.
Nansen location, August 3, 1895
Eva Liv I.
Freeden I.
NANSEN'S JOURNEY
Heading back to Norway after failing to reach the North Pole, explorers Fridtjof Nansen and Hjalmar Johansen spent the winter of 1895-96 in a make-shift hut on Jackson Island.
Nansen route, summer 1895
Northeastern Land Sound
Karl Alexander I.
Backs Channel
Rainer I.
HOFFMANN I. COLD WAR-ERA AIRFIELD Abandoned
Hoffmann I.
SEVERNOYE MILITARY BASE Abandoned 1994
Jackson Island
NANSEN WINTER HUT August 26, 1895-May 18, 1896
Italian Channel
Becker I.
Payer I.
Kuhn I.
Booth Channel
Kane I.
Greely I.
Rhodes Channel
Ziegler I.
La Ronciere I.
Vostok-1 Ice Cap
Vetreny Ice Cap
Graham Bell Island
Gage I.
Salisbury Island
Wiener Neustadt I.
Austrian
Morgan Strait
Wilczek Land
Tyndall Ice Cap
Champ Island
KRENKEL STATION Est. 1957
Josef
Hayes I.
Komsomolskiye Is.
Markham Sound
Channel
Newcomb I.
Alger I.
Moscow Ice Cap
Hall Island
Brady I.
McClintock Island
Hochstetter I.
Lavrova Sound
Salm I.
Wilczek I.
Sea
BIODIVERSITY
Wildlife in this frigid archipelago includes bowhead whales and Atlantic walruses. A large seabird population also survives here.
Little auk bird colony
Bowhead whale feeding site
Walrus rookery
0 mi 10
0 km 10
MARTIN GAMACHE AND LAUREN E. JAMES, NGM STAFF
SOURCES: MARIA GAVRILO, RUSSIAN ARCTIC NATIONAL PARK; ARCTIC AND ANTARCTIC INSTITUTE; WWF RUSSIA; IMAGICO; GLIMS; IHS



Nesting amid boulders on scree slopes or cliffs, little auks, like these whirling off the back side of Rubini Rock, sometimes make elliptical circuits—"carousel flights"—above their rookeries. No one knows why.



Scale worm

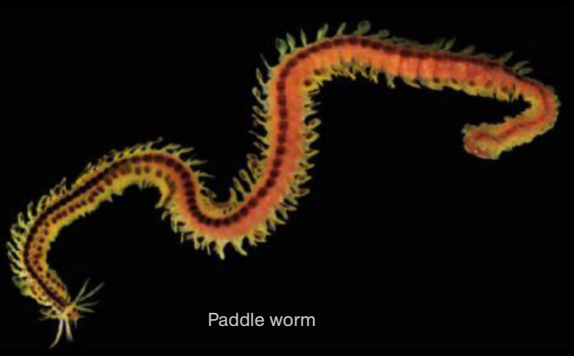


Sea angel

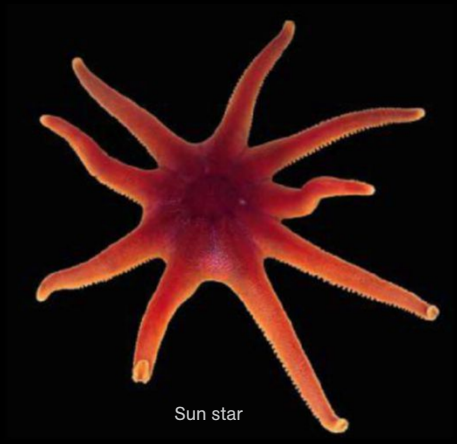
LIFE UNDER THE ARCTIC

Searching for life in the frigid waters, expedition divers saw few fish but a lively selection of invertebrates, representing five different phyla. You won't find any of these, brought up for closer examination, in your backyard pond.

ANDREY KAMENEV (ALL)



Paddle worm



Sun star



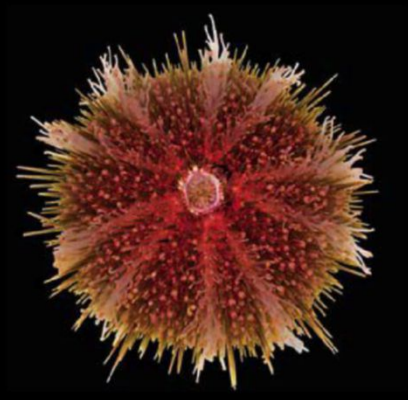
Boreal rosy margarite



Greenland cockle



Punctate blade shrimp



Pale sea urchin



Egg capsules of a whelk



Palm hydroid



Colonial bryozoan

pros from earlier expeditions, and he welcomed a dozen Russian colleagues besides Gavrilo. He brought in Paul Rose, from the Royal Geographical Society in London, for his polar diving and climbing experience, his problem-solving skills, and his ineradicable good cheer. To this distinguished group he added a handful of us media types. In late July 2013 we all sailed for Franz Josef Land, where the waters are certainly not warm or clear, and where the sea has remained nearly pristine because for so much of the year, at least until recently, it has remained largely frozen.

OUR TWO FRENCHMEN, David Grémillet and Jérôme Fort, have come to study the little auk *(Alle alle),* a black-and-white bird that nests on cliffs and amid scree boulders and dives for its food in the frigid water. The little auk is still abundant throughout the Arctic, with a population estimated at more than 40 million—one of the most numerous seabirds in the world. But its family kinship with the great auk, an icon of human-caused extinctions—the last known pair was killed in 1844 off the coast of Iceland for a bird collector—serves as a reminder that no species is invulnerable to the pressures we humans generate. Beyond that, Grémillet and Fort have other grounds for focusing on the little auk. It's a tiny bird, as seabirds go, second tiniest of the auk family, with small wings that allow it to swim underwater as well as through the air. Its energy costs and its metabolic rate are high. So if its environment changes, Grémillet tells me, the little auk may be more severely affected than other species. And its environment is changing—recent average temperatures in the Arctic are higher than they have been for the past 2,000 years. One study of Arctic trends projects further increases of as much as 14 degrees Fahrenheit by the end of this century.

The little auk feeds primarily on copepods, minuscule crustaceans that are the main component of Arctic zooplankton. Each bird needs to gobble thousands of them to make a square meal. "And these copepods, they have very specific temperature preferences," Grémillet explains. "So you can predict that if these

One bear strides toward us. Suddenly I feel as if we're just three pieces of dark meat on a very white plate.

copepod communities change because of climate change in the Arctic, the little auks will show a strong response."

How might the copepod fauna change? One of the larger and fatter kinds, *Calanus glacialis,* depends upon very cold water and the presence of sea ice, beneath which grow the algae that it eats. A smaller and leaner species, *Calanus finmarchicus,* is common in the North Atlantic and often rides currents into the Arctic but doesn't flourish there. As the Arctic Ocean warms by a few degrees, though, the competitive balance could shift. Higher temperatures and decreases in sea ice could allow the small, lean copepods to replace the big, fat ones, to the detriment of the little auk—and of other creatures as well. Arctic cod, herring, and various seabirds feed on the copepods, and even such mammals as ringed seals and beluga whales depend on fish that feed on them. That's why scientists consider *Calanus glacialis* a keystone species in the Arctic.

Grémillet and Fort catch little auks by laying out patches of "noose carpet" in which the birds get their feet tangled, and then each bird is weighed, measured, and banded. Some birds are also fitted with a time-depth recorder or a geolocator, miniaturized units affixed to a leg or to breast feathers, from which data can be retrieved. The geolocators will track migration routes south after the birds have bred. The time-depth recorders will reveal how deep a bird has dived, how long it has stayed down on each dive, and how many hours daily it has devoted to such laborious food getting. From earlier work on Greenland and Spitsbergen, Grémillet and Fort know that during winter little auks that have only *Calanus finmarchicus* to eat must forage up to ten hours a day to meet their energy needs. How much worse might it be if in summer, with chicks to feed and incubate, they have only that labor-intensive source of food?

So far little auks have shown admirable flexibility in the face of incremental change. But the question is, Fort says, how much further can they flex? "We think there will be a breaking point."

ON A MONDAY IN LATE AUGUST, after two tries, we succeed in reaching Cape Fligely, on the north coast of Rudolf Island, the most northern of the group. Here, while the others are variously focused, Paul Rose and I escape ashore for a hike to the top of the glacier.

We climb up from the beach cautiously, because two polar bears showed themselves hereabouts last night and one again this morning. But those animals seem to have ambled away, and the coast is clear. As always, we have a security man: another young Russian, Alexey Kabanihin, who carries flares, a radio, and a Saiga-12, its clip loaded with blank rounds preceding the real ones. It's a glorious sunny day. From the western cape where we've landed, a great dome of ice rises gently inland and upward, a smooth arc sweeping toward nothingness like the curvature of the moon. Far below, afloat

This Pristine Seas Expedition was generously supported in part by Blancpain, Davidoff Cool Water, and your National Geographic Society membership.

on the steel blue water, is the *Polaris.* In crampons, with ice axes, Rose and I start crunching up the slope, Kabanihin lagging behind. The ice is soft on its surface, beaded like corn snow, and sturdy beneath; the footing is good. After a day of shipboard confinement yesterday, Rose and I are thrilled with this getaway and can hardly control our foolish grins. But as we're nearing the top, a voice from Kabanihin's radio breaks our mood. It's Maria Gavrilo, saying: "Paul, the polar bear smells you. And is coming toward you. Climbing the glacier. I suggest you come down."

We look at each other. "Roger, Maria," Rose says. "That is all understood." He shuts her off. We have no idea that she's coping with an ugly situation below—too many of us now on the island, spread out, unresponsive to cautions, and bears moving about. Can we go ahead just a little? Rose asks Kabanihin, who shakes his head and gestures with crossed arms: absolutely *nyet.* But we're thinking: *da.* "One minute?" pleads Rose. When the poor young man cringes indecisively, we both take off running. With a combined age of 126 but adolescents at heart, Rose and I gallop away, onward, beyond reach of authority and good sense, to a point very near—if not exactly—the highest spot on the northernmost landmass of Eurasia. Get a GPS reading, I say.

He reports: 81 degrees, 50.428 minutes north. Elevation: 174 meters. I scribble those numbers in my notebook. Data. Then we run back to Kabanihin, who looks unhappy, though not as unhappy as he soon will.

Descending over the curvature of the dome, we see one polar bear between us and the ship, another bear off to our left. The bear in front is climbing toward us. The other is seated but turning its head as we move. I realize the situation is serious when Kabanihin hands me a flare. We shuffle on. Stay quiet, Kabanihin signals. Stay close. He seems very nervous. The glacier is big and open, and it belongs to the bears. We try to angle between them, but the one ahead closes that angle, striding toward us with purpose. Suddenly I feel as if we're just three pieces of dark meat on a very white plate. I keep an eye on the left bear, expecting it to charge while Kabanihin is distracted by the other.

Kabanihin sets his gun on the ice. He takes back my flare, unscrews the cap, and fires it toward—but not precisely at—the bear ahead. A red phosphorus Tinker Bell skitters across the ice. When that bear scampers leftward a few dozen strides, we have an opening to go.

We've been lucky. Getting ourselves killed, or getting a bear killed, Sala reminds us later, would have ruined the expedition.

ON THE NORTHEAST COAST of Hayes Island, near the middle of the archipelago, stand the remains of an old meteorological outpost known as Krenkel Station, which pulsed with activity during the Soviet era. Established in 1957, it grew to include several tall antennas held up by guy wires, a launchpad for smallish research rockets, a miniature rail line for moving supplies and equipment, and dozens of buildings. At its peak 200 people worked and lived at Krenkel. Now there are just half a dozen, and at least two dogs, a black-faced husky and a creamy one, which greet us curiously at the beach when Romanenko, Garankina, Fay, and I jump ashore.

Our presence has been cleared with the head of the station, and he leaves us to wander unsupervised through his little fiefdom of wreckage. Only the dogs come along.

The station thrived from about 1967 to 1987, according to Romanenko. Elsewhere in Franz Josef Land, a Soviet air base supported long-range bombers that took off and prowled the Arctic in nervy readiness, just as bombers from American bases did. But Krenkel Station was not part of that. It was scientific in purpose and even modestly internationalist, through a collaborative arrangement with French meteorologists launching similar research rockets elsewhere. Then came the big changes at the turn of the 1990s, as the Soviet Union approached its own breaking point.

We can scarcely imagine, we who didn't go through it, what that was like: a stressful, confused, and anxious as well as thrilling time for many Soviet citizens, and no doubt especially





Even among the ruins of Krenkel Station this Russian guard with the Pristine Seas Expedition goes armed. The threat is real: In 2011 a bear killed a resident.



Polar bears eat mainly ringed seals and bearded seals, captured on sea ice. On land they scrounge seabirds, eggs, even grass. This animal grazed for days below Rubini Rock—then chewed up the remote camera.



More than one empire has fallen since an Austro-Hungarian expedition came in 1873. More than one expectation has been debunked.

hard in the boonies, as the distant central government metamorphosed so shockingly. Franz Josef Land is as far into the boonies as you can get. Making matters worse, in 2001 Krenkel Station was devastated by a fire. Personnel were pulled out and not replaced. They left their little houses, their recreation center with its two pianos and its pool table and its library, and they boarded boats or helicopters that carried them back to the mainland. Romanenko seems to see all that in his mind's eye as we walk amid the ruins of this little polar station.

"C'est la fin de l'empire," he says, not complicating his French with past tense. The end of the empire. He's old enough to remember.

More than one empire has fallen since an Austro-Hungarian expedition came to these islands in 1873. More than one flag was raised here that no longer flies. More than one geophysical expectation, such as the existence of an Arctic continent, has been debunked. The North Pole is real, as a determinable if invisible point, but the early explorers such as Nansen, who came or went via this archipelago with their dog teams and their ice-riding ships, failed to reach it. Franz Josef Land has been a memorable waypoint on the glorious polar route toward frustration and disillusion. Its lonely flat-topped islands, with their parapets of basalt, stand as emblems of frigid adamance; they testify that, though men can be stubborn and resourceful and brave, nature is surpassingly complex and strong.

The remains of old Krenkel Station temper that testimony to nature's preeminent power in their ambivalent way: with hundreds of tons of industrial garbage and with delicate vestiges of the humanity of those who hunkered here.

Because the station is part of Franz Josef Land and because Franz Josef Land is within the administrative ambit of Russian Arctic National Park (though not yet enjoying full park protection itself), park authorities have initiated cleanup operations at Krenkel. They envision subsuming the site within a planned *muzey pod otkrytym nebom,* or great open-air museum. But they will face some delicate decisions about where remediation should stop and preservation begin. When a place lands on the junk heap of history, how do you tell what's history and what's junk?

Even more delicate, and far more consequential, will be decisions made in Moscow about renewed Russian military attention to the Arctic. In early November 2013, just two months after we finished our voyage, Defense Minister Sergei Shoigu announced plans to deploy a squadron of warships with ice-breaking capability to protect new trans-Arctic sea routes as well as potential oil and gas deposits. As of 2011, according to the Russian news agency Novosti, 95 percent of Russia's natural gas reserves and 60 percent of its oil reserves lie in the Arctic region, although most of the fields are beneath the Barents and Kara Seas, closer to the mainland. The pattern of the discoveries of those fields and the warming climate have encouraged Russia to look farther north. The defense minister's announcement even mentioned reopening the air base on Franz Josef Land. Will this proprietary

surge, if it happens, be compatible with protection of Arctic ecosystems? Enric Sala, a calm optimist, thinks it will. After all, Vladimir Putin himself is thought to harbor conservationist sympathies—but who can tell with Putin? Sala hopes that Franz Josef Land will soon receive full protection as a national park and reckons that a strengthened military presence "can actually help with enforcement."

THE QUESTION OF ICE underlying all these issues will not be answered by any one expedition. Measurements can be taken, photographs can be shot, comparisons can be made between ice coverage now and what early explorers saw, but the matter of causality is vast and intricate. The scientists on this team do what good field scientists always do: They gather quantitative observations of particulars. Making dive after dive in the freezing water, Alan Friedlander identifies 16 species of shallow-zone Arctic fish and begins pondering why diversity here seems to be low. Kike Ballesteros, likewise spending his days in a dry suit, with numbed fingers and reddened cheeks, makes a thorough inventory and biomass assessment of the marine algae, something never before done. Maria Gavrilo and her team census ivory gulls, kittiwakes, guillemots, little auks, common eiders, and glaucous gulls, measuring, weighing, banding, and placing geolocators on some. Forest Rohwer and his graduate student Steven Quistad capture billions of viruses from a variety of hospitable media, such as beach slime and guano, and will derive insights from sequencing their DNA back in a U.S. lab. Mike Fay identifies and collects more than 30 species of flowering plants. Daria Martynova samples the water column for copepods, gauging the penetration of that North Atlantic species *Calanus finmarchicus* into the Arctic realm of *Calanus glacialis.* Such efforts, and all the other observations gathered during this expedition, will help answer smaller questions within the big one.

Is the planktonic community changing? Are the kittiwakes and the guillemots reproducing as successfully as in the past? Have the sea-bottom fauna or the terrestrial flora been affected by trends of temperature change? Have the polar bears become more concentrated on islands, marooned there now that the sea ice has vanished from Franz Josef Land during summer? Have the planktonic changes, if any, had a discernible effect on the population of little auks? This is ecology—everything interconnected. The whole body of data and analyses will be pulled together within coming months into a compendium report under Sala's editorial eye.

Through the end of our journey and beyond, I carry vividly in memory a moment that occurred near the beginning, while I was ashore on Hooker Island with the Frenchmen. We had spent a long afternoon with their noose carpets deployed, getting only modest results. They had caught and processed three little auks. It wasn't enough data, and at that rate they would need to change their tactics or choose a different site. Then, as Fort and I gathered our gear to depart, Grémillet spotted an adult auk hiding between the boulders, where auks place their nests. He grabbed it. Doing that, he spotted something else: a chick. He grabbed the chick too and turned to us, an auk in each hand. Measuring and banding a bird takes two hands; extracting a blood sample takes four. These two scientists, after a slow day, were suddenly busy. So Grémillet handed me the chick. I accepted it in my cupped hands, with a high sense of privilege, and tried to shield it from the wind.

Little auks have long lives, up to 20 years, and reproduce slowly, one chick a year. Each chick is precious. The period from hatching to fledging, the most vulnerable time in an auk's life, is about 25 days. This chick had just hatched. It was a ball of fluffy black down, the size of a plum, with a beak. Trusting and helpless. After a short time I passed it gingerly back to Grémillet, and he returned it to its nest.

Recalling the moment now, I wonder where that particular bird is. I wonder whether it survived its 25 days in the rocks, fledged, and flew away from Franz Josef Land to a wintering ground somewhere, an exemplary little auk, intrepid and resilient. □

The Hidden World of the Great War

The Lost Underground of World War I

BY EVAN HADINGHAM

PHOTOGRAPHS BY JEFFREY GUSKY

THE ENTRANCE IS a wet hole in the earth little bigger than an animal burrow, obscured by thorny brush in a secluded wood in northeastern France. I'm following Jeff Gusky, a photographer and physician from Texas who has explored dozens of underground spaces like this one. Together we slither through the muddy hole into the darkness below. Soon the passage opens up, and we crawl forward on hands and knees. The glow from our headlamps wavers along the dusty chalk walls of the century-old tunnel, which slopes away from us



A hundred years ago in a subterranean chapel, an unknown artist carved this image of a French soldier praying. Artwork covers many abandoned passages under the western front.





The scars of artillery barrages still pockmark the ruins of a fort at Chemin des Dames, where some 30,000 French troops died during ten days in April 1917. Underground, French and German forces tried to penetrate each other's tunnels, and sometimes they fought hand to hand in pitch-black passageways.





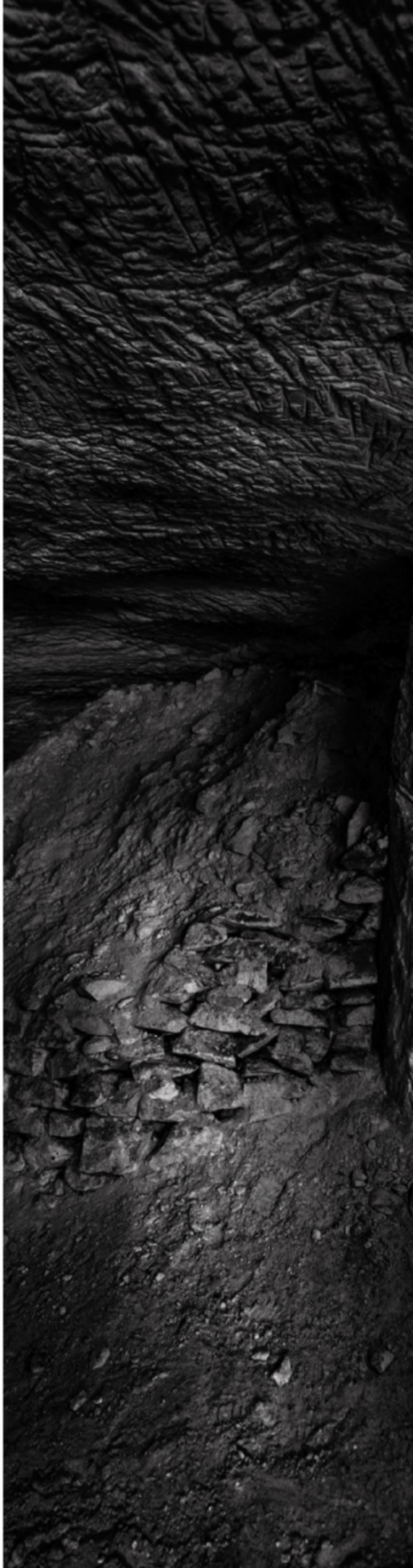
The deadlock of trench warfare led both sides to tunnel beneath enemy positions and plant explosives. In the Oise Valley, German engineers dug this secret network of tunnels beneath the French front lines. On January 26, 1915, they detonated a charge that killed 26 French infantrymen and wounded 22.



down into the shadows. After a few hundred feet the tunnel ends at a little cubicle hewed out of the chalk, reminiscent of a telephone booth.

Here, shortly after the outbreak of the First World War—which began a hundred years ago this summer—German military engineers would take turns sitting in total silence, listening intently for the slightest sound of enemy tunnelers. Muffled voices or the scraping of shovels meant that a hostile mining team might be only yards away, digging an attack tunnel straight toward you. The danger grew if the digging stopped and you heard the sound of bags or cans being quietly stacked, one on top of another. It signaled that the enemy was laying high explosives at the end of the tunnel. Most nerve-racking of all was the silence that followed. At any moment the charges might detonate and blow you apart or bury you alive.

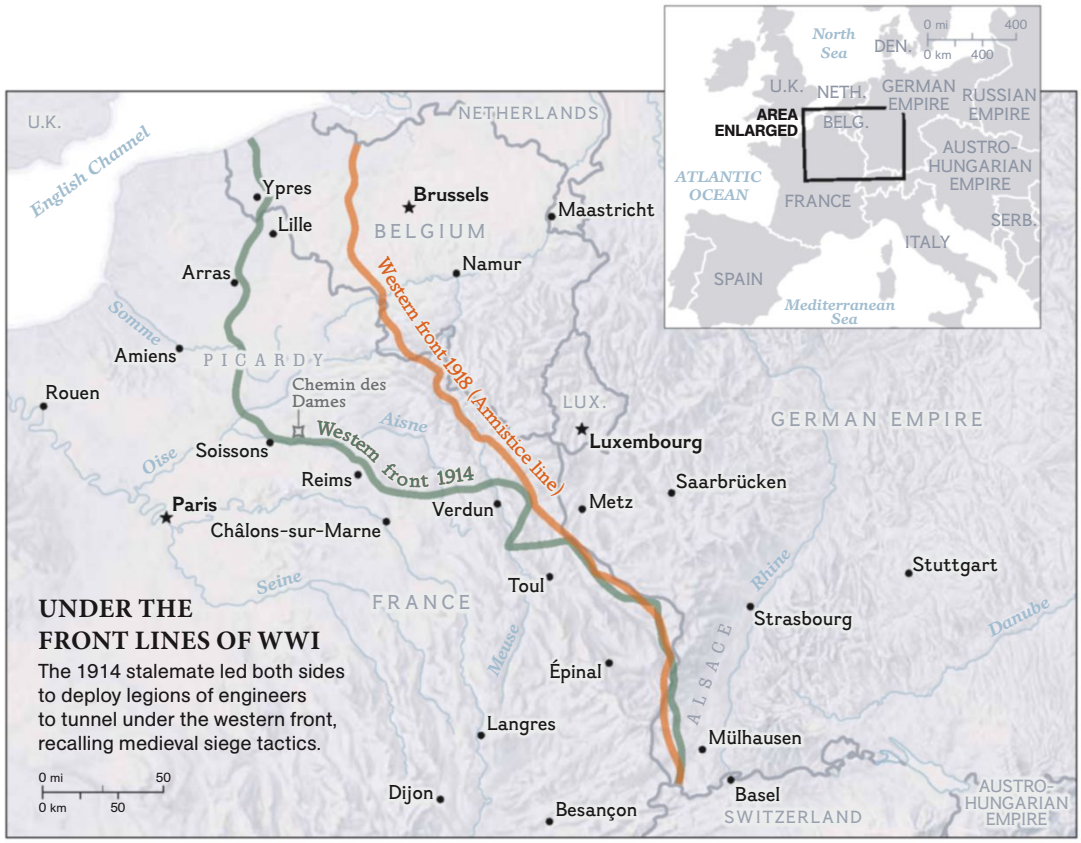
Nearby, on one of the tunnel walls, our headlamps illuminate graffiti left by the German engineers who manned this listening post. Their inscribed names and regiments are crowned by a motto: *"Gott für Kaiser!* (God for the Kaiser!)." The pencil marks appear fresh, as if they were written yesterday. In fact, the soft chalk and



French sappers use a ground stethoscope to listen for enemy movement in neighboring tunnels (above). U.S. troops of the 26th "Yankee" Division, billeted in an underground quarry at Chemin des Dames (right), carved some 500 engravings during six weeks in 1918. These include names, addresses, religious and patriotic symbols, and other images.

PHOTOS: ADOC-PHOTOS/CORBIS (ABOVE); COMPOSED OF TWO IMAGES (RIGHT)


FRED J.B ROPER
NED
PERRY
USA
COADY
C.O.A
O.I.M.G. BN.
1918
H.C.



limestone bedrock of France's Picardy region was ideal not only for mining operations but also for World War I soldiers to record their presence in penciled signatures, sketches and caricatures, carvings, and even intricate relief sculptures. This underground art is relatively unknown beyond a circle of World War I scholars and enthusiasts, as well as village mayors and landowners, many of whom Gusky has spent years getting to know.

His images bring to light the subterranean world soldiers endured while sheltering from constant shellfire. They left names, images of women, religious symbols, cartoons, and more. These traces, Gusky says, illuminate a forgotten world of World War I, connecting us to the individual soldiers, many of whom would not survive the nightmare of trench warfare.

Evan Hadingham is the senior science editor for NOVA. *Jeffrey Gusky is a fine art photographer and emergency physician in Dallas, Texas.*

The conflict began with mounted cavalry and confidence on all sides that it would all be over by Christmas. By the end of 1914 the German advance had stalled, the armies had dug in, and an extensive network of trenches stretched from the North Sea coast to the Swiss border. An arms race led to the first mass use of poison gas, air warfare, and tanks. On the western front, millions of troops died in largely futile offensives and counterattacks.

In the grip of this deadly stalemate, the Germans and their French and British adversaries resorted to siege-warfare techniques that had changed little over the centuries. The goal was to dig under key enemy strongpoints and blow them up; counterattacks were thwarted by setting off charges to destroy their own tunnels. At the height of the underground war, in 1916, British tunneling units detonated some 750 mines along their hundred-mile sector of the front; the Germans responded with nearly 700 charges of their own. Hills and ridges that provided vital lookout

PRE-WWI BOUNDARIES SHOWN. ALEXANDER STEGMAIER, NGM STAFF; SPRINGER CARTOGRAPHICS. SOURCE: PIERRE PURSEIGLE, YALE UNIVERSITY

points became riddled like Swiss cheese, while the biggest mines blew out huge craters that still scar the landscape to this day. Even a single small mine could wreak havoc: In the tunnel complex we crawled into, a charge set off by the Germans on January 26, 1915, killed 26 French infantrymen and wounded 22 more.

But the underground war was not confined to narrow tunnels. Beneath Picardy's fields and forests are centuries-old abandoned quarries, some of which could shelter thousands of troops. On a misty morning we explore one such site, located along a cliff edge overlooking the Aisne Valley. We're led there by the owner of the ancestral property, which we agree not to name to protect the quarry from vandals.

He proudly shows us a monumental carving of Marianne, the classic French symbol of liberty, guarding the entrance to the quarry. Beyond, in the gloom of the man-made cavern, we peer at an array of finely engraved badges and memorials proclaiming the French regiments that had sheltered here. And we come upon several chapels elaborately carved and painted with religious symbols, army insignia, and the names of notable French victories. The landowner shows us a stone stairway that led from one of the chapels to the fury of exploding shells and machine-gun fire in the front lines above. "My heart stirs when I think of all the men who climbed these steps and never came back," he says.

Life in the quarries was vastly preferable to the muddy hell of the trenches above. A journalist visiting one of the caverns in 1915 noted that "a dry shelter, straw, some furniture, a fire, are great luxuries for those returning from the trenches." They kept an even temperature year-round, but as one French soldier wrote home, "vermin devour us, and it's teeming with lice, fleas, rats and mice. What's more, it's very humid and a lot of the men fall sick." To pass the time, the exhausted men would daydream. Images of women proliferate on the quarry walls, including many sentimental and idealized portraits.

Both sides converted the largest quarries into underground cities, many of them remarkably intact today. Not far from the landowner's property, we hike across the potato fields of a farm owned by his cousin. A young man in his 20s, he had reclaimed the land by personally collecting dozens of unexploded mortars, grenades, and shells, some containing still lethal poison gas, which the army took away and detonated.

Beneath his potato field, we find ourselves in an astonishing labyrinth, a medieval quarry that stretches for more than seven miles, with twisting passageways and high ceilings reminiscent of a subway station. In 1915 the Germans connected this vast warren to their frontline trenches. They installed electric lights and telephones, command posts, a bakery and butcher's, a machine shop, a hospital, and a chapel. Although thick with rust, the original diesel generator and barbed wire defenses are still in place. So are dozens of street signs neatly stenciled on every corner, essential reference points in the disorienting maze of passages. On the cavern walls German troops have inscribed their names and regiments, religious and military icons, elaborately sculpted portraits and caricatures, and sketches of dogs and other cartoons.

Among the most prolific decorators of the underground cities was the 26th "Yankee" Division, one of the first U.S. units to reach the front following America's entry into the war in April 1917. To visit the quarry where they were billeted at Chemin des Dames, we climb down two wobbly ladders into a cavern 30 feet below. We spend hours exploring a hundred-acre complex. Our headlamps reveal an extraordinary time capsule of the war: passageways strewn with countless bottles, shoes, shell cases, helmets, beds made of rusted chicken wire, even an entire cooking range with pots and pans still in place.

For six weeks beginning in February 1918, these passages were filled with the sounds and smells of hundreds of American men. Mostly raw recruits, they were rotated in and out of the quarries to their first experience in the trenches above. The men spent hours decorating every square inch of certain walls. We pick out dozens of religious and patriotic symbols: insignia of the Freemasons and Knights of Columbus; portraits of Uncle Sam, Buffalo Bill; and caricatures of the



A relief of Field Marshal Paul von Hindenburg (left), a key leader of the German war effort, peers out from a quarry wall. Portraits of famous figures cover the walls of the underground. Other passages feature images of Kaiser Wilhelm, French Prime Minister Georges Clemenceau, and U.S. President Woodrow Wilson, as well as carvings of Buffalo Bill and Uncle Sam.

Some soldiers used their art to comment directly on the war, as in this carving of the ship *Liberty* (right), sinking beneath "the disasters of the 20th century." The artist, a French soldier whose regiment was almost completely wiped out at the battle of Chemin des Dames, may have been despairing over the staggering casualties or protesting German attacks on civilian shipping.





A French cavalry officer is depicted on the wall of a quarry (left). At the war's outset, cavalry forces were part of all the opposing armies and hearkened back to an age of chivalric warfare. But within weeks of the war's outbreak in 1914, barbed wire and machine guns rendered traditional mounted attacks obsolete. Instead, horses ferried supplies, weapons, and wounded men.

A rough carving of a cat (right) may have been a wistful nod to the rodents that were rife belowground. Many soldiers ignored politics and passed their time engraving whimsical cartoons of pets and other animals. "Comic images of the everyday world provided mental relief from the overwhelming stress of the battlefield raging above," notes photographer Jeff Gusky.





The haunted stare of a German infantryman (left) hints at the horror of trench warfare. Germany suffered more than six million casualties during World War I, including the conscript Erich Maria Remarque, who was wounded by shrapnel. He went on to write, in *All Quiet on the Western Front,* "We had suddenly learned to see. And we saw that there was nothing of their world left."

Occasionally artists seemed to combine gallows humor with grim utility, as in the image of a mustachioed soldier impaled by a rusty nail (right). Soldiers hung their clothing, gear, and provisions from nails to allow them to dry. Such hooks also helped protect the items from rats, mice, and other vermin.





Private Archie Sweetman of the 26th Yankee Division carved his self-portrait (left) as a resolute doughboy and inscribed it with his name while billeted in a quarry at Chemin des Dames during early 1918. The Boston-born Sweetman survived the war with a minor injury.

A woman is shown wearing large hair bows (right), a style associated with the traditional costume of Alsace, a disputed region that Germany relinquished to France after World War I. Female images are found throughout the underground, from caricatures to idealized portraits of wives and girlfriends as well as of patriotic symbols, such as Marianne, the French emblem of liberty and reason.





kaiser. Among the penciled names my eye falls on is "Earle W. Madeley," a corporal from Connecticut who notes he is "aged 20 years." Records show Madeley was killed on July 21, 1918, one of 2,000 deaths inflicted on the Yankee Division before the November armistice.

Safe underground from the inhuman chaos of the battlefield above, the men of the First World War left these personal expressions of identity and survival. But this unique heritage from the war is under threat. When vandals tried to saw off the image of Marianne, the outraged landowner fitted metal bars on all of his quarries. At the Yankee Division quarry, a retired auto mechanic dedicated to safeguarding it built hefty metal gates and installed padlocks. But many other sites remain at risk from vandals and thieves.

The auto mechanic secures the lock, and we walk back to the car. As the bitter January wind blows across the battlefield, I ask him why a quarry filled with American names is so important to him. He reflects for a second, then replies, "By reading the names of the men down there, we make them live again, for a moment." □



Troops left the relative comfort of an underground quarry via a carved stairway leading up to the trenches (above). Some quarries could shelter thousands of men and featured amenities such as electric light. By 1918 combined tank, artillery, and air attacks made battlefields more mobile, and armies began to abandon their underground redoubts.



NATIONAL GEOGRAPHIC ON TV



Urban Jungle

A coyote howling in the hills is one thing. A coyote prowling the streets of Chicago is another. This month the National Geographic Channel reveals a world of wildlife living in our midst. Join big cat tracker Boone Smith (left, surrounded by bats in Austin, Texas) as he tries to understand the many creatures now cohabiting with us, from raccoons in Toronto to baboons outside Cape Town.

MOVIES



DEEPSEA CHALLENGE Filmmaker James Cameron (left) is also an ocean explorer, driven by a dream to be the first man to dive solo to the bottom of the Mariana Trench. Opening August 8, this film chronicles his voyage and documents the never-before-seen organisms that thrive in Earth's deepest place. See *deepseachallenge.com* for theater listings.

MYSTERIES OF THE UNSEEN WORLD High-speed photography and nanotechnology are just two of the scientific advancements that bring the invisible to life in this film. More at *nationalgeographic.com/movies.*

TRIPS

AFRICAN ADVENTURES Always wanted to climb Kilimanjaro? Or ride a camel across the Sahara in Morocco and then sleep under the stars? Here's your chance. Book at *ngadventures.com/travel.*

EXHIBIT

MARS UP CLOSE This interactive exhibit in Washington, D.C., puts you on the red planet. Highlights include profiles of NASA scientists and a full-scale model of the Curiosity rover (right). Visit *ngmuseum.org* for more information.



Book of the Month



Healthy at Home Tieraona Low Dog, M.D.

Sometimes the cure for what ails you is right under your nose. In this innovative book Tieraona Low Dog—an expert in natural healing—offers home remedies for everything from coughs and colds to headaches and insomnia. Full of recipes and dosing instructions, this guide for drug-free wellness is on sale now wherever books are sold ($26).

PHOTOS (FROM TOP): JAKE HERRLE, NATIONAL GEOGRAPHIC CHANNELS; KENN BROWN AND MONDOLITHIC STUDIOS

Invited for Dinner

Every Saturday morning the cars lined up outside the Gateway Baptist Church on the outskirts of Houston, Texas, each waiting for a box of donated food. Photographer Kitra Cahana walked from car to car to ask if any of the families would let her see inside their lives.

Cahana was one of three photographers who shot this month's story on hunger in the United States. While she worked with families in Houston, Stephanie Sinclair shot in New York's Bronx, and Amy Toensing in rural Iowa, each giving different faces to the same statistic: One-sixth of Americans don't have enough food to eat. Photographing such an intimate story about people's struggles required added empathy. "All three photographers had to know how to get people to allow them into their homes—and what to say when they got there," says *National Geographic* senior photo editor Susan Welchman.

In the line of cars in Houston, Cahana encountered six-year-old Vivian Latson (below) and her parents. They invited Cahana for dinner that night. When she arrived, each person was given a corn dog and a sandwich made of white bread, a slice of meat, and Cool Whip. *—Daniel Stone*



Photographer Kitra Cahana



PHOTO (TOP): MARK THIESSEN, NGM STAFF



Air Apparent French troops during World War I prepare a Caquot observation balloon, likely inflating it with hydrogen for launch. One of the craft's stabilizing fins, deflated, droops over the side. Balloons like this did not travel across the sky but were tethered to the ground and could rise as high as 4,000 feet. A wicker basket dangled beneath, manned with a lookout to direct fire or report on enemy activity.

The January 1918 *National Geographic* (in which this photo appeared) was devoted entirely to articles about the war—which the United States had entered only in April of the previous year—and flight. Stories included "Aces of the Air," "Flying in France," and "Italy's Eagles of Combat and Defense." "Aviation is a game—an amazing game," wrote Capt. Jacques De Sieyes in the issue, "a game of adventure, of countless thrills, of soul-stirring excitement, a game in which courage, daring, resource, determination, skill, and intelligence achieve honor in life or, if the fates so decree, glory in death." *—Margaret G. Zackowitz*

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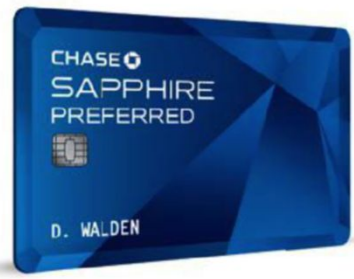
PHOTO: PAUL THOMPSON, NATIONAL GEOGRAPHIC CREATIVE

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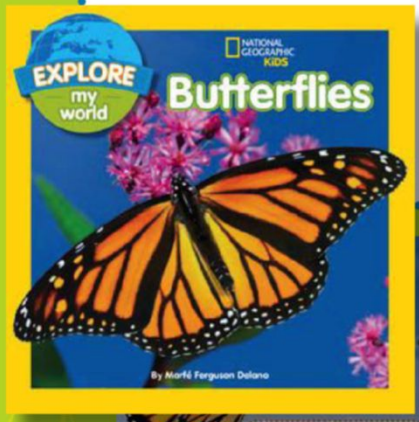
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